94th Congress
2d Session

COMMITTEE PRINT

THE U.S. BUREAU OF MINES

PREPARED BY THE

SENIOR SPECIALIST DIVISION
CONGRESSIONAL RESEARCH SERVICE
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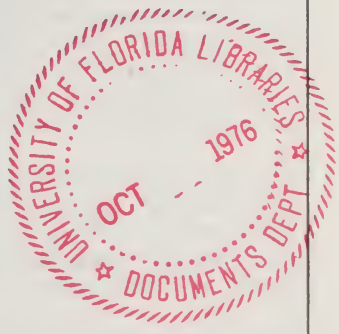
AT THE REQUEST OF

HENRY M. JACKSON, *Chairman*
COMMITTEE ON INTERIOR AND
INSULAR AFFAIRS
UNITED STATES SENATE

SEPTEMBER 1976



U.S. GOVERNMENT PRINTING OFFICE
75-682 O WASHINGTON : 1976

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MEMORANDUM OF THE CHAIRMAN

To Members of the Senate Committee on Interior and Insular Affairs:

Mining is one of the several sources of new wealth which comes from natural resources, along with agriculture, hunting and fishing, and forestry.

Clay, gold, iron, copper, and tin, mined from the earth, were essential for making implements, for building, for trade, for jewelry, and for cosmetics during the several thousand years before the industrial revolution. In the past two centuries, hundreds of new minerals and dozens of new elements have been identified, and have been put to use through the complex hardware that serves society today.

Transportation, communication, and construction have been revolutionized partly by the materials that have thus become available in recent years—such as titanium in space and aircraft vehicles, rare earths for color TV tubes, alloy steels for slender yet strong bridges, and high-rise buildings. Modern agriculture owes much to the mineral fertilizers, such as phosphates, potash, and nitrates.

In ancient societies, underground mines were dug to depths of several hundred feet. In the 19th century the steam engine and the air compressor enlarged significantly the energy that was applied to mining—a great advantage over human muscle. The introduction of the steam shovel in open-pit mines just before World War I was another milestone in the continuing move toward increased productivity.

Mineral deposits are not equally distributed around the world, so the United States, although well endowed with many commodities—which have served as the basis for a thriving mining industry—is nevertheless dependent on other countries for many minerals and elements. Not only must solid minerals such as manganese and chromium be imported—almost totally—to satisfy U.S. consumption, but also a growing percentage of U.S. consumption of petroleum must come from abroad.

Accordingly, the United States has increased and must increase further its search for new mining and metallurgical technologies, which will permit the Nation to replace some of these imported commodities. Because mineral deposits are a wasting asset, mining must be planned in such a way as to maximize the profit over the life of the deposit.

Therefore, mineral conservation is exceedingly important, and technological advances have played a huge role for many decades by permitting the extraction of lesser and lesser values.

But, to extract minerals from underground results in changes in the natural environment, not only through the hole in the ground created by the mining process but also through the construction of access roads, powerlines, and water supply facilities, and through the disposal of wastes. Thus, along with more economic mining has come the greater attention paid to repair the resulting environmental disruptions.

Organized efforts to prevent injuries and occupational diseases in the mining industry have been of comparatively recent origin in the United States, beginning about the turn of the 20th century. Mining, especially underground mining, is more hazardous in many respects than are most other major industries, and increasing attention has been given to its health and safety aspects.

In 1910, the U.S. Bureau of Mines was born from the U.S. Geological Survey, to deal with problems of safety to miners. In 1973 the regulatory aspects of mine health and safety were divorced from the research aspects; thus the Mining Enforcement and Safety Administration was born to serve the regulatory function, while the Bureau of Mines retained the research function.

In the last 65 years, additional functions have been added to the Bureau of Mines by the Congress, in response to changing needs involving mining and related technologies. The Bureau's several program areas—mining, metallurgy, engineering-environment-evaluation, and data collection and analysis—are supported by appropriations totaling more than $150 million annually.

In the process of doing all of these research, development, and demonstration activities, several of the Bureau's programs have come under criticism in recent years. These, as well as present and future program directions of the Bureau, plus an account of the 65-year history of its activities, together consititute the substance of the report which follows.

The Committee on Interior and Insular Affairs has oversight responsibility for the activities of the Bureau of Mines. To aid the committee in its continuing review and evaluation of these activities this report was prepared at my request by Dr. Allen F. Agnew, senior specialist in environmental policy (mining and mineral resources) of the Congressional Research Service of the Library of Congress. I have directed that it be published at this time, for the information of committee members and other interested parties.

Henry M. Jackson,
Chairman.

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Prepared by

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at the request of

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United States Senate

September 1976

THE U.S. BUREAU OF MINES

Summary

HISTORY

Established in 1910 as a spinoff from the U.S. Geological Survey, the U.S. Bureau of Mines has put more than 65 years of effort into solving problems connected with extracting and processing the minerals which have enabled the United States to become the foremost industrialized nation in the world.

President Theodore Roosevelt, with the strong backing of other conservationists and the mining industry and others, had recommended in 1907 that a Bureau of Mines be established in the Department of the Interior. However, it was not until a series of disasters occurred in the Nation's coal mines, in December 1907, that public attention became focused on this tragic waste of human resources and natural resources in mines and plants of the mineral industries.

The Bureau's early work contained a large element devoted to health and safety of miners; this emphasis continues today, although the regulatory aspects are now handled by a new agency, the Mining Enforcement and Safety Administration (MESA), which was spunoff from the Bureau of Mines in 1973 because of a desire to separate regulation from research and development. The charge in the Bureau's Organic Act of 1910 [1] was to investigate the methods of mining, including especially:

(1) The safety of mines, and the appliances best adapted to prevent accidents;

(2) The possible improvement of conditions under which mining operations were carried on;

(3) The treatment of ores and other mineral substances;

(4) The use of explosives and electricity; and

(5) The prevention of accidents.

In addition to health and safety, the Bureau has also placed much attention throughout its history on the treatment of ores and other mineral substances, as was spelled out in the 1913 amendment to the Organic Act,[2] which described the Bureau as one of mining, metallurgy, and mineral technology, with the following functions.

(1) To conduct inquiries and scientific and technologic investigations concerning mining, and the preparation, treatment, and utilization of mineral substances with a view to improving health conditions, and increasing safety, efficiency, economic development, and conserving resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries;

(2) To inquire into the economic conditions affecting these industries;

[1] 36 Stat. L. 369.
[2] 37 Stat. L. 681.

(3) To investigate explosives and peat;

(4) To investigate, on behalf of the Government, the mineral fuels and unfinished mineral products belonging to or for the use of, the United States, with a view to their most efficient mining, preparation, treatment, and use; and

(5) To disseminate information concerning these substances.

The early mineral statistics-gathering effort of the Geological Survey (mainly fuels) was strengthened in the new Bureau of Mines. Similarly, technological investigations of the engineering aspects of mine problems were enlarged, with the establishment in 1915 of 7 mine-safety stations and 10 mining experiment stations; by 1921 there were 13 of the latter and in addition, 12 field offices had been established.

Throughout its history, new programs have been added to the Bureau by Congressional legislative authorizations. Thus its programs have responded to needs perceived both in-house and from outside, as expressed through the enactment of specific legislation.[3]

PRESENT PROGRAM

The Bureau's programs deal with all phases of the mineral cycle except for the first stages, which are the concern of the U.S. Geological Survey. The Bureau works closely with the USGS in the transition area from "exploration" to "development" (Fig. S–1). The Bureau's programs deal with scientific and technologic investigations, with the collection and dissemination of mineral information, and with analysis and recommendations on U.S. minerals policy (Fig. S–2). Beginning with an annual appropriation of less than half a million dollars in its first year, the Bureau's funding today is more than $150 million (Fig. S–3 and Table S–1).

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[3] One program from the 1913 Amended Act (No. 4, above) was transferred to another entity of the Department of the Interior in 1920 when the Mineral Leasing Act was signed, and its function is now performed by the U.S. Geological Survey.

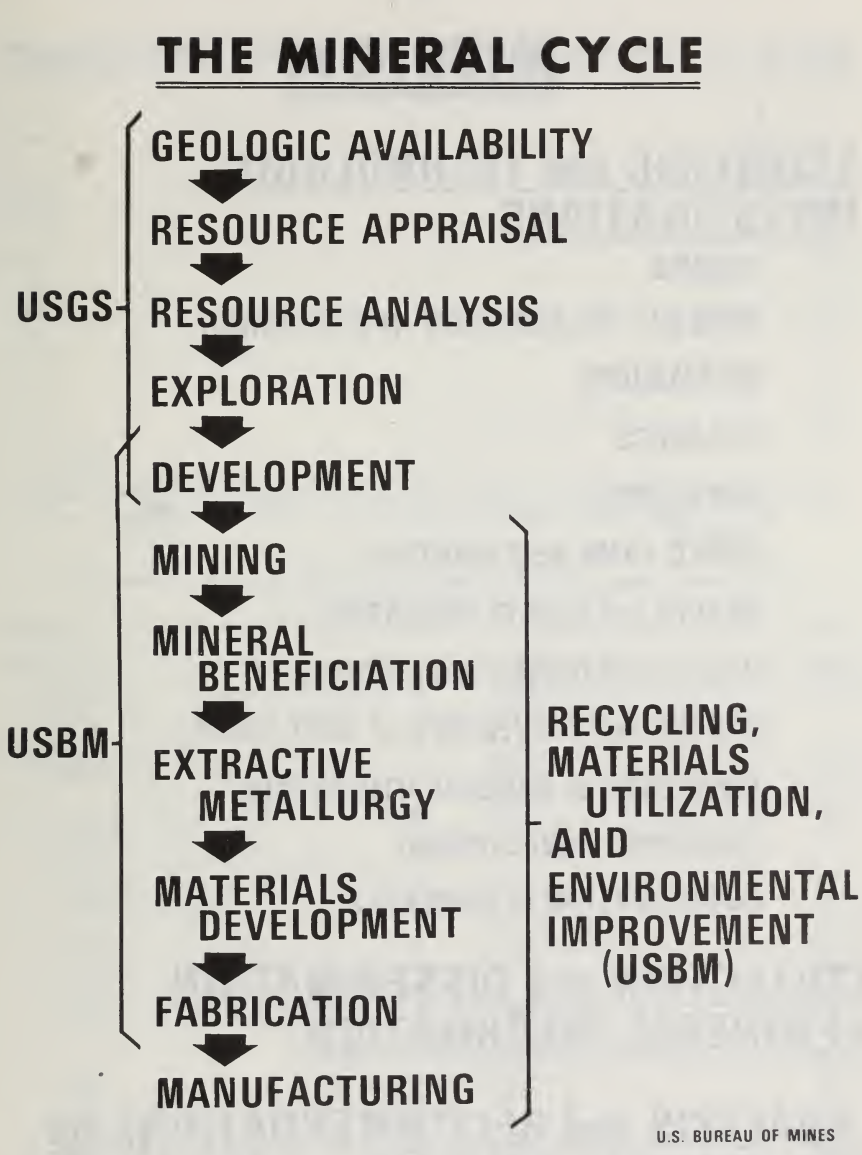

FIGURE S–1.—Activities of Bureau of Mines related to the minerals cycle.

MISSION

SCIENTIFIC and TECHNOLOGIC INVESTIGATIONS

MINING

MINERAL PREPARATION (PROCESSING)

METALLURGY

CERAMICS

RECYCLING

MINED LAND RECLAMATION

HEALTH and SAFETY RESEARCH

USE of EXPLOSIVES and ELECTRICITY

CAUSES and PREVENTION of MINE FIRES

EFFICIENCY of MINERAL UTILIZATION

ECONOMIC DEVELOPMENT

CONSERVATION of MINERALS

COLLECTION and DISSEMINATION of MINERAL INFORMATION

ANALYSIS and RECOMMENDATIONS on U.S. MINERAL POLICIES and PROGRAMS

J.S. BUREAU OF MINES

FIGURE S–2.—Missions of the Bureau of Mines.

Figure S-3. APPROPRIATED FUNDS, BUREAU OF MINES, FY's 1911-1976

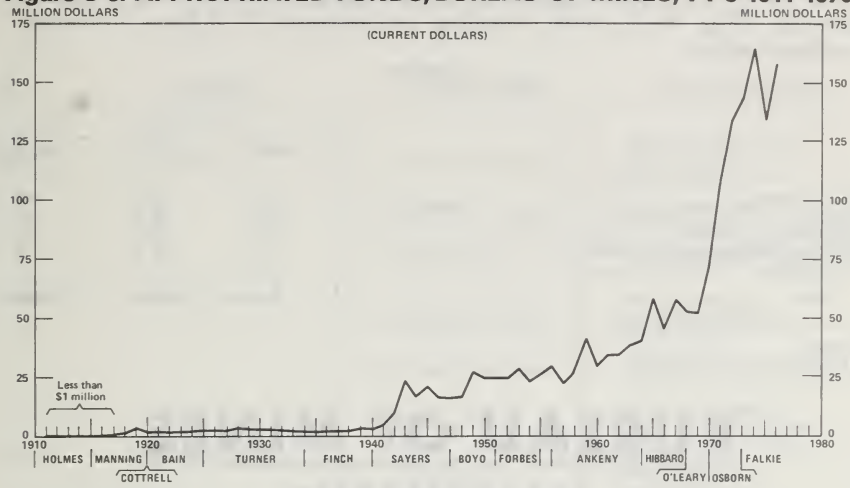

FIGURE S–3.—Appropriated funds, Bureau of Mines, fiscal years 1911–76.

Table S–1.—Funds appropriated to Bureau of Mines, 1911–76 (current dollars)

Year:	*Millions*	Year—Continued	*Millions*
1911	$0.5	1944	$16.9
1912	.5	1945	20.5
1913	.6		
1914	.7	1946	16.5
1915	.7	1947	16.0
		1948	16.3
1916	.8	1949	27.0
1917	1.0	1950	24.1
1918	1.5		
1919	3.2	1951	24.7
1920	1.2	1952	24.5
		1953	27.8
1921	1.4	1954	22.7
1922	1.5	1955	25.5
1923	1.6		
1924	1.8	1956	29.5
1925	2.0	1957	22.2
		1958	26.1
1926	2.1	1959	41.4
1927	1.9	1960	29.1
1928	3.1		
1929	2.7	1961	33.6
1930	2.5	1962	34.1
		1963	37.7
1931	2.6	1964	39.6
1932	2.3	1965	58.2
1933	1.9		
1934	1.2	1966	44.9
1935	1.4	1967	57.7
		1968	52.3
1936	2.0	1969	51.5
1937	2.1	1970	72.0
1938	2.2		
1939	3.1	1971	108.5
1940	2.9	1972	133.2
		1973	143.4
1941	4.2	1974	164.3
1942	9.2	1975	133.8
1943	23.9		
		1976	157.4

Source: Annual Reports of Director, USBM; Annual Reports of the Secretary of the Interior.

The Bureau of Mines in recent years has maintained five program elements (Fig. S–4), with varying proportions of dollars invested, as shown below:

[In percent]

	Fiscal year—		
	1975 [1]	1976 [1]	1977 [2]
Mining research	67.0	63.5	69
Metallurgy	15.0	19.0	14
Data collection and analysis	9.0	10.0	10
Engineering, evaluation and demonstration	7.5	6.5	6
Administration	1.0	1.0	1
Total	99.5	100.0	100

[1] Actual.
[2] Requested.

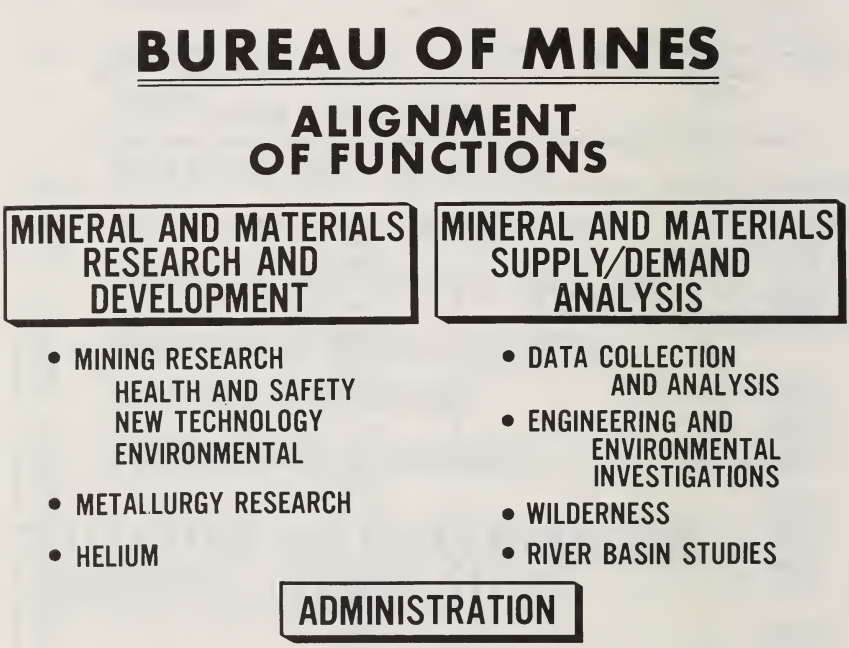

FIGURE S–4.—Alignment of functions of Bureau of Mines.

The Bureau's Mining Research activities in the past couple of years have been divided about 60 to 40 between mining technology and mining health and safety, respectively. Thus, although the regulatory activities regarding mine health and safety now reside in MESA, the Bureau of Mines invests about 40 percent of its dollars in research that is specifically designed to support that important segment of the mining operations. There are separate public laws and authorized activities pertaining to health and safety for coal mining on the one hand, and for metal and nonmetal mining on the other—which apply to both MESA and the Bureau. The Bureau puts 85 percent of its health and safety effort on coal mining (Fig. S–5).

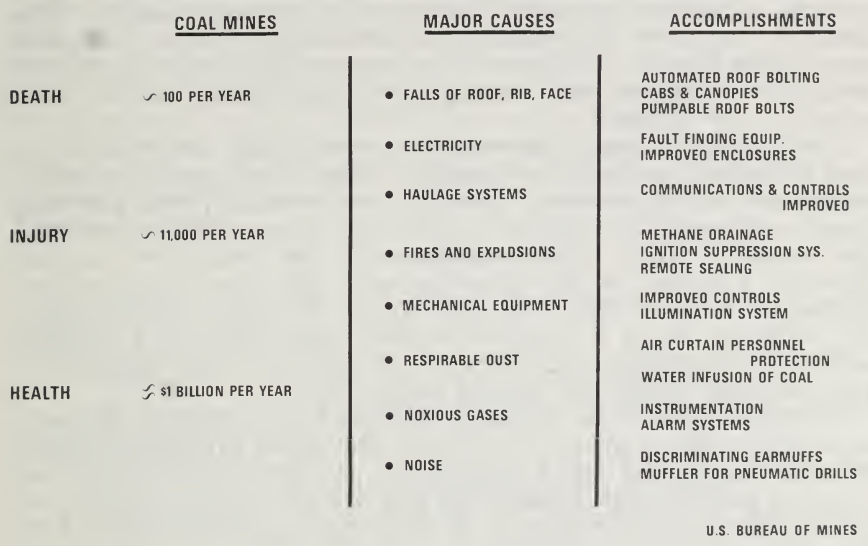

FIGURE S–5.—Health and safety problems.

In conducting its mining technology studies, the Bureau applies 80 percent of its effort to coal, with the remainder divided approximately equally between oil shale on the one hand and metals and non metals on the other.

The Bureau's Metallurgical activities, although receiving less than one-fourth of its total dollars, have contributed some of the more outstanding advances in the mineral industries. As with its mining research program, the Bureau's metallurgy program is conducted in close cooperation with industry. Whereas initial laboratory investigations are usually performed by the Bureau itself, when pilot-plant and larger demonstration-plant stages are reached it frequently acquires industry participation in terms of dollars as well as plant facilities and personnel. This permits the Bureau to be more responsive to problems as perceived by the industry, and allows the Bureau-developed technology to be scaled up and transferred more rapidly and efficiently so that production increases can result.

In fiscal year 1976 the Bureau's metallurgical program consisted of several program elements, as follows:

	Percent
Advancing minerals technology	38
Desulfurization of stack gas	20
Minimizing mineral and metal needs	11
Pollution abatement	9
Secondary resource recovery	8
Alumina pilot plant	7
Uranium ore processing	4
Geothermal	2
Energy use patterns	1
Total	100

In the area of data collection and analysis, the Bureau budgeted 82 percent of its activity for fiscal year 1976 in gathering minerals information, 16 percent for liaison activities with the States, and the remaining 2 percent on analysis of the U.S. mineral position. The Bureau's two new computerized data-handling system, Minerals Availability System (MAS) and Fuels Availability System (FAS), are designed to improve the thoroughness and efficiency of the data collection and retrieval.

Many of the Bureau's better-known publications are produced as part of the data collection and analysis effort. These periodical publications are issued monthly, quarterly, and annually, and deal with specific commodities, and with domestic (by State) and international (by country) trade. These culminate in the well-known annual *Minerals Yearbook*, in which are gathered individual chapters pertaining to the three categories just named. The useful *Mineral Facts and Problems*, which is published every 5 years, presents a synoptic look at each commodity industry, which includes a most helpful diagram showing supply and demand relationships.

A unique feature of the Bureau is its State liaison program, whereby one of its specialists resides in each State and serves as a communicator between the Bureau and State officials and universities, as well as with the local mining industry. In this manner, a beneficial flow of information among these several important segments of the U.S. minerals community is enhanced.

The Bureau of Mines' mineral position analysis has become one of its more important efforts since 1970, as a result of the Mining and Minerals Policy Act of 1970—which requires the Secretary of the Interior to report annually on the status of the mineral industries, with recommendations.

A number of activities are included in the program designated as Engineering, Evaluation, and Demonstration. In fiscal year 1976 these included the following:

	Percent
Pennsylvania anthracite mined land areas	45
Wilderness areas	22
Engineering and environmental studies	17.5
Mine subsidence, Rock Springs, Wyo	12
River basin studies	2.5
Control of fire in inactive coal mines and waste piles	2
Total	100

The Pennsylvania anthracite mined-land investigations and demonstrations, performed with substantial funding from the Appalachian Regional Commission, attempt to extinguish fires both underground and in mine-waste piles, prevent surface subsidence, and design acid-mine drainage corrective measures.

The wilderness studies, performed in conjunction with the U.S. Geological Survey as a sequel to the latter's basic investigations, constitute a significant program that affects mineral resources on Federal lands. As originally defined in the Wilderness Act, both "instant" and "study" areas were specified, and the joint USBM/USGS studies were programed to cover these huge areas within a 20-year period which ends in 1984. However, this program has become

a very dynamic one, as Congress adds more areas to the Wilderness System each year—thus increasing the burden on the two agencies to complete their mineral assessments by the designated date.

The engineering and environmental investigations program element consists of providing advice and comment on environmental problems related to the mineral industries, as directed by the National Environmental Policy Act, through Federal interagency committees and land use planning groups at Federal, State, and local levels.

In addition, this program element includes mineral studies of certain Alaskan Native Land Claims, as well as technological and economic studies of problems related to the development of mineral deposits in Alaska.

RECENT ACCOMPLISHMENTS

Numerous Mining Research advances in health and safety have resulted, including the following:

—Reduced dust levels in coal mines by deeper cuts in coal, water sprays on cutting heads, and reduced bit speed.

—Development of a portable battery-operated respirable dust-recording mass monitor.

—Development of a noise-suppressing earmuff that permits the wearer to hear low-level warning signals and speech.

—Demonstration of technology for de-gassing the Pittsburgh bituminous coal seam ahead of mining.

—Development of an inexpensive, continuously recording methane meter, which is both accurate and reliable.

—Development of two new types of passive water barriers, effective against dust explosions.

—Reduction of roof-bolting injuries was shown by development of (1) a bolt bender-inserter and (2) remote drilling techniques.

—Demonstration showing that the microseismic technique was the best for predicting roof falls.

—Development of a call-alert system, using UHF radio, which showed that reliable voice communications can be maintained between a portable unit in the mining area and the surface of the ground.

—Development of a miniaturized mine-monitoring and telemetry system, to record four critical parameters—methane, ventilation, carbon monoxide, and temperature; it also computes the rate of rise in temperature.

—Testing and approval by NIOSH (National Institute of Occupational Safety and Health) of two self-contained emergency-breathing pieces of equipment for use underground, one having a 10-minute and the other a 1-hour supply of oxygen.

—Development of a dust-control technique for a mill-bagging operation, reducing the dust dispersed throughout the mill by 90 percent—although the dust exposure to the bagger was reduced by only 20 percent.

—Demonstration of a yielding rock-bolt, which was able to maintain its support capability while undergoing significant rock displacement (a fully grouted resin bolt performed equally well, but the conventional expansion-shell bolt did not).

In mining research there were advances in technology also, as shown by the following examples:

—testing of two alternatives to the conventional drill-blast cycle for primary rock breakage, which showed considerable energy savings—(1) thermal-mechanical and (2) thermal-hydraulic methods.

—Identification of inefficient and unsafe operations, by a comprehensive analysis of ore-handling systems in underground metal and nonmetal mines.

—Designing an underwater test for determining the hazards of materials that are marginally explosive; because of its successful test, this technique is being considered by the ASTM (American Society for Testing Materials).

Numerous Metallurgical advances have resulted from work of the Bureau of Mines. Selected examples include:

—Reduction in manufacturing cost of thin-walled titanium castings, with an increase in their strength, by using zircon-sand molds instead of the conventional rammed graphite ones.

—Development of a simple flotation process for economic recovery of potassium sulfate from brine in the Great Salt Lake.

—Substitution of low-rank coals in a continuous rotary kiln for fire-hardening high-grade iron-ore pellets for shipment and smelting; conventionally, gas or oil are used as fuel.

—Designing a process to recover copper from copper blast-furnace slags.

—Development of a new chlorine leaching-electrolytic scheme for recovery of lead and zinc from sulfide ores but without the liberation of as much sulfur dioxide as by conventional processes; also, it can recover lead and zinc from complex ores, and uses less energy.

—Development of a simple procedure to remove trace amounts of the toxic element, selenium, from wastewaters of mineral processing plants that produce zinc.

—Devising a polyurethane-recovery process, in cooperation with two major oil companies, which will recover that plastic from the padding in seat cushions and insulation; this recovery would not only ease a serious waste-disposal problem, but also would conserve the valuable petroleum raw materials from which the plastic is made.

—Development of a technique using a special flux and solder, which will permit field repair of brazed aluminum heat-exchanger units; heretofore, field replacement of copper by aluminum in these heat exchangers has been hampered because of the close temperature control required.

—Designing a flame-spraying process, 15 times as fast as the current one, for applying the nickel catalyst to the reactor surfaces in the catalytic-conversion step of coal-gasification processes for upgrading low-Btu gas into high-Btu fuel.

—Successful application of carbon-in-pulp cyanidation in the recovery of silver from low-grade ores and processing-plant wastes.

—Adoption by industry of a new method for the production of mischmetal, a mixture of rare-earth metals.

In the area of Data Collection and Analysis, the Bureau continues to produce the annual *Commodity Data Summaries*, and a new publication series was begun, entitled *Minerals and Materials; a Monthly Survey.*

Specific reports were published, dealing with the Florida phosphate industry, the economic and capital-generating capability of 21 leading domestic coal-producing companies, and the energy use by the U.S. mineral industry for some 80 mineral commodities.

A mathematical model was developed through a university contract, for calculating the cost of various levels of reclamation of surface coal mines.

In addition, the Nation's coal reserves were assessed and the results were published in two summary documents dealing with the "Demonstrated Coal Reserve Base of the United States on January 1, 1974," in 1974 and, by sulfur content, in 1975. The basic data for these reports were published, for underground mines, in two information circulars, issued in 1974 (Eastern United States) and 1975 (Western United States).

In the program of Engineering, Evaluation, and Demonstration, the Bureau made several strides, as shown below:

—For the mined land investigations and demonstrations element, (1) subsidence control over previously mined-out areas of anthracite by injection underground of a pumped slurry of mining wastes at Scranton, Pa., and (2) a similar program at Rock Springs, Wyo., where underground bituminous coal mining had been the cause of subsidence.

—Control of four coal-bed fires, in Colorado, Montana, and Utah.

—Completion of reports on the impacts of copper-nickel mining in northeastern Minnesota, and on the mineral resources of the trans-Alaska pipeline corridor.

FUTURE PLANS

The Bureau, in line with a general realization by the executive branch that broad-scale mineral problems have arisen in recent years which are of major concern to the United States, has developed a series of nine strategic objectives to reduce their impact, as follows:

1. Increase productivity/production in minerals and related materials industries (fig. S–6);
2. Reduce waste of minerals and energy;
3. Expand availability of minerals;
4. Improve reliability and utilization of data and analysis;
5. Enhance safety and health of workers (fig. S–6);
6. Reduce social and environmental costs;
7. Minimize vulnerability of supplies;
8. Improve response to demand for domestic minerals; and
9. Promote a national manpower pool needed for the increased production and utilization of domestic minerals.

TARGETS OF HEALTH AND SAFETY AND COAL MINE RESEARCH

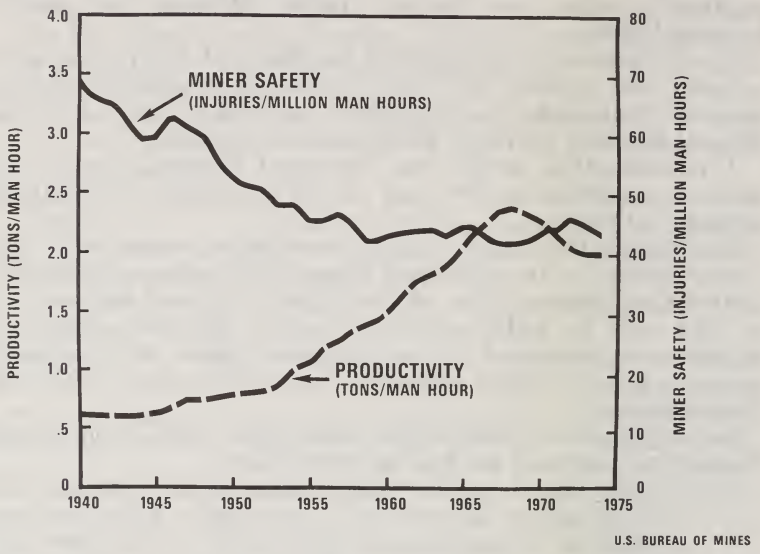

FIGURE S–6.—Targets of coal mine health and safety research.

RECENT CRITICISMS

Several of the Bureau's programs have been targets of criticism in recent years, partly because of changed perceptions by the executive branch and the Congress—brought about by changes such as the greater attention given to environmental matters and to government-industry relations—and partly because of delays or inadequate performance related to insufficient funding and personnel, with inflation being a contributing cause. Six specific cases are discussed.

The purpose of the helium program, as seen by the Bureau, is to provide an assured and sustained supply of helium that is sufficient for essential governmental activities. The Bureau's program has been one of conservation and production, but the production of helium for conservation purposes has been interrupted and several lawsuits have been filed against the Federal Government because of the Interior Secretary's termination of the crude helium-purchase contracts; five deal with determining the reasonable value of helium in the natural gas that is delivered by industry to the helium-extraction plants, and four deal with the charge of breach of contract by the United States for the sale and purchase of a helium-gas mixture.

The Energy Research and Development Administration (ERDA) published in April 1975 the results of a study of the energy applications of helium, in which it concluded that the old crude-helium purchase program should not be reinstated because the issue is very complex, as shown by recent court decisions. The ERDA report made four recommendations:

1. The Federal Government should facilitate the storage of privately owned helium in Government-owned fields;

2. The Federal Government should establish a helium-management and helium-pricing policy consistent with the objectives of No. 1, taking into account the benefits and costs to the public;

3. The Federal helium program should continue to be administered by the Bureau of Mines; and

4. The Federal Government should improve its knowledge of how much helium exists in gas deposits that are not likely to be consumed for fuel purposes.

Other critics of the helium program, testified in May 1975 that the Federal program should be redirected toward the possibility of extracting helium from the atmosphere—an unlimited source. The ERDA report had stated that the cost in dollars of helium extraction from the atmosphere is estimated to be several hundred times the present price from existing plants, and that the energy cost of extracting the helium used in 1974 would equal 16 percent of the 1974 production of bituminous coal (600 million tons).

The second issue deals with areas of conflict that have involved two other Federal agencies—ERDA and MESA. The ERDA/USBM issue deals with coal research, wherein duplication and inadequate coordination have been perceived by some Members of Congress and the General Accounting Office (GAO). The GAO reported in February 1975 that the establishment of ERDA should be a major step in developing a unified coordinated Federal coal research program.[4]

The House Appropriations Subcommittee on Interior stated that H.R. 3474, the ERDA authorization bill, "proposes to duplicate or supersede the present effective and ongoing [mining-related energy] research so ably conducted by the Bureau of Mines." [5] The House Science and Technology Committee, however, stated that the general ERDA authority provided for that agency "to be involved with research and development for all aspects of the fuel cycle for fossil fuels," and that Section 103 directs ERDA to "exercise central responsibility for public planning, coordination, support, and management of research and development programs respecting all energy-sources." [6]

The issue centers on the Office of Coal Research, which was transferred to ERDA [Public Law 93-438] from the Interior Department under a continuation of its original directive to "develop through research, new and more efficient methods of mining, preparation, and utilizing coal." [7]

Language clarifying the intent of the act was added to both the House and Senate Government Operations Committee reports, to keep the act from authorizing research and development work by ERDA which would duplicate work being done by the Bureau of Mines, as follows:

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[4] GAO, Federal Coal Research—Status and Problems to be Resolved: General Accounting Office Report RED-75-322, Feb. 18, 1975, p. 31.

[5] Letter from subcommittee Chairman Sidney R. Yates and ranking minority member Joseph M. McDade to House Science and Technology Committee Chairman Olin B. Teague, Apr. 14, 1975.

[6] Letter from Teague to Interior Secretary Rogers Morton, Apr. 21, 1975.

[7] Public Law 86-599, which established the Office of Coal Research.

Research on coal mining technology, including coal analysis and preparation, as well as the use of coal for metallurgical processes will be continued by the Bureau of Mines, especially as such research relates to mining and metallurgical technology or mine health and safety * * *. These include responsibility for mining metals and minerals, mine health and safety, mined area reclamation * * *." [8]

The other agency-conflict issue, between MESA and the Bureau of Mines, developed because the definition of the separation between the regulatory functions of MESA and the research functions of the Bureau had not been interpreted uniformly by the two agencies. The focus of most issues between the two agencies was the MESA program element called technical support and the question of the dividing line between its support services and the research function of the Bureau of Mines. Relative funding for these two functions in fiscal year 1976 is $12.1 million for technical support in MESA and $34.9 million for research on mine health and safety in the Bureau of Mines.

When the conflict between the agencies became evident in late 1974 and early 1975, the Interior Department's Assistant Secretary for Energy and Minerals, Jack Carlson, sent a memo to the heads of the two agencies on June 26, 1975, which left management of the research in the Bureau, but gave greater control over the establishment of priorities for some of the research program to MESA.

A joint Interior Department/Bureau of Mines/MESA Task Force developed procedural mechanisms and evaluation criteria which both bureaus followed in formulating their fiscal year 1977 programs. A strategy paper is to be prepared, outlining the goals and priorities for research on health and safety—both short range and long range. A memorandum of understanding covering the interface obligations of both Bureaus was signed by the Bureau Director and the MESA Administrator, on February 6, 1976.

There have been many additional constructive interactions, and Bureau of Mines Director Thomas V. Falkie and MESA Administrator Robert E. Barrett were able to assure the House Science and Technology Subcommittee on Fossil Fuels on February 11, 1976, that the matter has now been resolved and the two agencies are operating in a coordinated and mutually supportive manner.

A third issue which has resulted in criticism of the Bureau is that of shortcomings in the mineral data and analysis program. The primary issue of tardiness in mineral statistics involves a number of factors, which the Bureau has answered as follows:

1. Although the bound volumes of the *Minerals Yearbook* are not usually delivered until more than 2 years after the close of the calendar year reported upon, numerous other products are available within several months after the end of the year—beginning with a brief summary sheet based upon preliminary numbers for each commodity and State within 1 month, and revised summaries of several pages issued a few months later.

2. Other products are also published within a month of the availability of the data; examples are monthly and quarterly *Mineral Industry Surveys*, *Minerals and Materials: A Monthly Survey*, and the annual *Commodity Data Summaries*—the latter being a most useful presentation of data on supply and use of each commodity, together with information on domestic and foreign

[8] Report to accompany S. 2744, Senate Government Operations Committee: 93d Cong., 2d sess., Sen. Rept. 93-980, June 27, 1974, p. 36.

reserves, U.S. imports and exports, tariffs and depletion allowance, as well as stockpile information.

The other issue related to mineral data and analysis pertains to the *Annual Report of the Secretary of the Interior under the Mining and Minerals Policy Act of 1970*. The first (1972) and second (1973) reports, prepared largely by the Bureau, identified policy issues and repeated them. Each report was backed up by an appendix, the Bureau's *Commodity Data Summaries* referred to above. In 1974 the Bureau's appendix was published, but the Secretary's Office did not bring forth the policy document.

The Interior Department's Office of Policy Analysis took over the preparation of the policy document for 1975—which is very similar to the one for 1973.[9] The Bureau's commodity data summary for 1975 is not called an appendix to the Secretary's report, but it, along with other documents now being produced by Interior's Office of Policy Analysis, are used as background for the policy document.

A fifth issue that has brought criticism upon the Bureau of Mines in the past year or so has dealt with the costs of the proposed Federal surface mine legislation of 1975. In the spring of 1975, the Congress was considering two bills that contained many compromise positions which had resulted from 8 years of hearings and staff effort on numerous pieces of legislation in both the Senate and the House.

President Ford had pocket-vetoed S. 425 in December 1974, but it had been reintroduced in the 94th Congress as S. 7 and H.R. 25. In February 1975, the administration presented its opposition to H.R. 25 in a hearing before the House Committee on Interior and Insular Affairs, noting that the Federal Energy Administration had said that it would cause the loss of coal production during the first year of 48–141 million tons (and proposing an administration bill which, the President said, would cut this loss to 33–80 million tons). The Administration bill, Interior Secretary Morton averred, would hold production losses within acceptable limits while at the same time providing reasonably needed protection of land and environmental values.

The Administration's numbers were challenged by House Interior Subcommittee Chairman Udall, who recalled that the loss claimed by the administration originally (November 1974) would have been 31–187 million tons per year.

Still in February 1975, the Administration made a similar presentation before the Senate Committee on Interior and Insular Affairs, wherein Interior Assistant Secretary Carlson repeated the loss number of 48–141 million tons of production, and added that there would also be a loss of 46,980 jobs (55 percent in mining jobs and 45 percent in associated industries).

However, 2 months later these numbers had changed again, when FEA Administrator Zarb wrote the House and Senate conferees that coal-production losses would be 40–162 million tons under S. 7, or 62–162 million under H.R. 25. Furthermore, he said that 10,000–36,000 jobs would be lost and that there would be the following additional financial costs to consumers: coal taxes of $130–$204 million, production and reclamation costs of $171 million, and Federal and State enforcement costs of $100–$160 million.

[9] And similar to the recommendations contained in the 1973 final report of the National Commission on Materials Policy.

Following passage of H.R. 25 by both the House and the Senate, President Ford vetoed it on May 20, 1975, because of (1) loss of jobs, (2) higher costs to consumers, (3) greater U.S. dependence on foreign petroleum, and (4) unnecessary reduction in coal production. Senator Metcalf rebutted those reasons, noting that in February, Secretary Morton had told the House subcommittee that enactment of surface mining legislation would result in a net gain in employment because of the additional people employed in the reclamation effort; further, Senator Metcalf reminded the President, the lost-production numbers had never been adequately explained by the Federal Energy Administration or the Interior Department.

At the invitation of the Congress, the Administration attempted to justify its numbers on June 3, 1975, in a joint hearing of three Congressional Interior subcommittees—two from the House and one from the Senate. Using an analysis furnished by the Bureau of Mines Director Falkie, FEA Administrator Zarb attempted to answer the criticism of the Congress and the Nation's press.

The joint hearing was followed by several exchanges of correspondence between Subcommittee Chairwoman Mink and Dr. Falkie, and critical statements in the *Congressional Record* on June 6, 1975, by her, by Senator Jackson, and by Congressmen Melcher and Ruppe.

An Environmental Protection Agency study, which halved the FEA-Interior coal-production losses, was quoted by the *New York Times*, and the *Chicago Tribune* reported on a private consultant's preliminary study for FEA which gave even lower numbers of production loss.

The House failed by three votes in its attempt to override the veto on June 10, 1975.

On June 30, the *Baltimore Sun* and the Louisville *Courier Journal* presented critiques by their reporters, who had spent the intervening 3 weeks on a study of the methods used by the FEA and the Bureau of Mines experts to compile their numbers.

On March 8, 1976, during hearings on the Energy Information Act (S. 1864), FEA Administrator Zarb and Interior Assistant Secretary Fisher were again grilled on this matter of the Administration's claims of coal-production tonnage that would be lost by a Federal surface-mining bill, this time by the Senate Interior Committee's Subcommittee on Energy and Power under Senator Haskell. Messrs. Zarb and Fisher were quizzed at length, with considerable emphasis being placed on the lack of Administration reply to questions asked of President Ford by Senators Jackson and Metcalf in letters in the summer of 1975, concerning questions raised in the articles in the *Baltimore Sun* and the Louisville *Courier Journal*.

The matter has not yet been resolved.

The sixth issue, wherein the Bureau of Mines has come under criticism in the past few years, is the inadequacy of its data-gathering and analysis effort. A General Accounting Office report of December 2, 1975, criticized this effort as needing (1) more current information, (2) more uniformity in the preparation of mineral estimates, and (3) review procedures that would improve their accuracy and reliability. On the other hand, a detailed study of energy statistics, conducted by the Survey and Investigations staff of the House Appropriations Committee, concluded in March 1976, that the Bureau has one

of the best systems of gathering, analyzing, and publishing meaningful data that exists in the Federal government.

The GAO had also reported on the Federal Government's needs for energy data and analysis on February 6, 1974. That report had expressed its concern over duplication of such effort among several Federal agencies.

The Energy Research and Development Administration (ERDA) authorization bills of 1975 (S. 598 and H.R. 3474) likewise focused on duplication of data-bank activities, as does the Energy Information Act (S. 1864). The latter (which was discussed in the preceding paragraphs herein, dealing with the surface-mining issue) has four principal purposes:

1. Establish an independent Federal agency to collect, analyze, and disseminate energy data and information;
2. Coordinate and consolidate the Federal collection of energy data, to minimize duplication in reporting;
3. Establish standards for handling this information, gathered from individual companies, so as to balance the public's right to know and private industries' right to confidentiality; and
4. Authorize a Federal program to locate the extent and value of the domestic energy resources of the United States.

In March and April 1976, hearings were held on S. 1864 in the Senate Interior Committee, under Subcommittee Chairman Haskell, who had introduced an amendment that would establish a National Energy Information Administration which would be independent of the executive branch. The NEIA would include the energy-information functions of the Bureau of Mines and the Federal Energy Administration. Although administrative and industrial witnesses opposed the bill, it was supported by numerous others from the Congress, State government, public-interest groups, and universities.

The Energy Information Act (S. 1864) had not gone to Senate markup by the middle of July 1976, nor had the House held hearings on its similar legislation (H.R. 7683). However, some of its provisions were included in legislation to extend the life of the Federal Energy Administration.

I. Establishment and Purpose of the U.S. Bureau of Mines

"The Bureau of Mines conducts research and development into protection in coal mining. It has made notable contributions to improvements of metallurgical and other processes. Its basic research has resulted in the development of new metals." That was the statement of the Second Hoover Commission, just 20 years ago.[1]

The Bureau of Mines had been established by an act of May 16, 1910, in the Department of the Interior, under a director appointed by the President with the consent of the Senate.[2] The Bureau was charged to investigate the methods of mining, expecially in relation to the safety of miners; the Secretary of the Interior was directed to transfer to the Bureau of Mines from the Geological Survey the supervision of the investigation of structural materials and the analyzing and testing of coal, lignite, and other mineral fuel substances, and the causes of mine explosions. The latter provision was modified by the Sundry Civil Appropriation Act of June 25, 1910, which directed the transfer of the investigation of structural materials to the Bureau of Standards.[3]

A new organic act for the Bureau of Mines was approved on February 25, 1913, which, although increasing the scope of its work by adding the treatment of ores and other mineral substances and other investigations pertinent to the mineral industries, did not affect its status as a bureau of the Department of the Interior.[4]

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[1] "Research and Development in the Government," a report to the Congress by the Commission on Organization of the Executive Branch of the Government, May 1955, p. 38.

[2] 36 Stat. L. 369; p. 703, 765; *Department of Interior, Annual Report 1910*, v. 2, pp. 24-25; Institute for Government Research, *The Bureau of Mines*, 1922.

[3] 36 Stat. L., 269, 272; *Department of Interior, Annual Report 1910*, 44.

[4] 37 Stat. L. 681; *Department of Interior, Annual Report 1916*, 535.

II. History of the U.S. Bureau of Mines

A. THE FIRST 40 YEARS [1]

Technologic branch of the USGS [2]

For some years before 1910, as mining and metallurgy progressed from arts toward the nature of sciences, demands had been made in many quarters [3] for a Federal Government bureau that would collect, evaluate, and disseminate scientific, technologic, and economic data of value to the mineral industries. Conservationists joined the mining and other advocates of such an agency, and in 1907 President Theodore Roosevelt recommended the establishment of a Bureau of Mines in the Department of the Interior. The Congress, however, did not adopt this recommendation until a series of disasters in the Nation's coal mines had focused public attention on the waste of human resources and natural resources in mines and plants of the mineral industries.

From its beginning in 1879, the U.S. Geological Survey had established a close relationship with the mining and mineral industries through the preparation and publication of its annual report on *Mineral Resources of the United States*. This relationship was strengthened by the studies that the USGS was making in important mining areas, by investigations and publications beginning in 1894 that related to technologic processes, and by publication of parts of a geologic map of the Nation—which covered areas of interest to the mining community. In 1899, USGS Director Charles D. Walcott recommended the establishment of a Division of Mines and Mining, to undertake a systematic inquiry into the value of the deposits of several economic minerals.[4]

The first effective response to this suggestion came in 1904, when Congress appropriated $30,000 for analyzing and testing the coals of the United States; [5] in 1905, this appropriation was enlarged to $227,000 and its provisions were extended to cover all fuels [6]—and another appropriation was made which provided for an investigation of structural materials. The work of fuel testing was begun in 1904 at St. Louis by Dr. Joseph A. Holmes, who continued it there until 1907 when the equipment was removed.[7] Other fuel-testing laboratories were established in 1907–1909 at Columbus, (Ohio), Pittsburgh, (Pa.) and Washington, D.C.[8]

[1] Derived largely from unpublished draft manuscript of February 15, 1954, in the files of the U.S. Bureau of Mines p. 37–61; this untitled report deals with the work, organization, and facilities of the Bureau. Part II, on programs of the Bureau of Mines, contains a section on the Bureau's history.

[2] Derived largely from Powell, Fred W., *The Bureau of Mines; Its History, Activities and Organization:* New York, D. Appleton and Company, 1922, 162 p.

[3] Although some of the interests of the mineral industries had been served by the U.S. Geological Survey since its inception in 1879, there was a growing demand for special recognition and aid from the Federal Government, especially among the metal-mining interests in the Western States and the bituminous coal-mining industry in the East. The first concrete proposal was in 1896, when the American Mining Congress at its initial annual convention, in Denver, proposed the creation of a national department of mines with representation in the President's Cabinet. From time to time thereafter, bills for the establishment of a separate organization were introduced into the Congress, with the ultimate result coming in 1910. (Powell, 1922, p. 1)

[4] Powell, 1922, p. 2.

[5] 33 Stat. L., 15, 33.

[6] 33 Stat. L., 602, 603; 33 Stat. L., 1156, 1187.

[7] The equipment was set up and the work was carried out at the Louisiana Purchase Exposition in 1904 in 1907 part of it was removed to the Jamestown Exposition at Norfolk, and part to Denver.

[8] 34 Stat. L., 697, 726; 34 Stat. L., 1275, 1335; 35 Stat. L., 317, 349; and 35 Stat. L., 945, 989.

On April 2, 1907, the Secretary of the Interior established a technologic branch in the USGS to conduct the work of testing fuels and structural materials, and Dr. Holmes was appointed chief technologist. The duties of the new branch were extended in 1908 [9] and 1909 by acts that appropriated $150,000—

> * * * For the protection of lives of miners in the territories and in the District of Alaska, and for conducting investigations as to the causes of mine explosions with a view to increasing safety in mining.[10]

This was partly the result of urging by the American Mining Congress, but the immediate cause was the newly awakened interest of Congress as a result of a series of disastrous coal-mine explosions in December, 1907.

Under the 1909 appropriation the technologic branch made examinations of explosives used in coal mines, and of safety lamps and mine-rescue apparatus. It also conducted inquiries into the occurrence of explosive gases and flammable [11] or explosive dusts and into the use of electricity in mines—done principally at Pittsburgh.

In 1908, stations equipped with mine-rescue apparatus and manned with personnel trained in first-aid and rescue methods were established in Pittsburgh and Urbana (Ill.) and, in 1909, additional stations were established in Knoxville (Tenn.) and Seattle (Wash.). In this manner it was possible to provide aid immediately after mine explosions, and to train miners in first-aid methods and for rescue work.

Creation and Development of the Bureau of Mines

By fiscal year 1909 the appropriations for the USGS technologic branch's three activities had reached a total of more than $500,000 and, despite the reduction in dollars in fiscal year 1910 for fuel testing, it was evident that the investigation of mining accidents would increase in both cost and importance. Because of three factors:

> (1) the lack of close connection between this engineering-technology work and the geologic work of the USGS,
>
> (2) the growing realization of the waste of both life and material resources in the mining and metallurgical industries, and
>
> (3) the insistence of the organized mining interests of the nation that they be given representation in the Federal Government,

a proposal was made for the creation of a Bureau of Mines as a separate branch of the Department of the Interior, charged with the conduct and development of the mining-technologic work. The result was the Organic Act establishing the Bureau of Mines.[12]

This act authorized the Secretary of the Interior to transfer to the new bureau the three types of investigations heretofore conducted by the technologic branch of the USGS, together with the pertinent property, equipment, and personnel. The Bureau of Mines became functional on July 1, 1910, and Dr. Holmes was appointed its Director shortly thereafter, serving until his death in July 1913.[13]

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[9] 35 Stat. L., 184, 226.

[10] 35 Stat. L., 945, 989.

[11] "Flammable" means capable of burning; "inflammable" is commonly used as a synonym, but it should be reserved for material that can be set aflame rather than that which flames spontaneously.

[12] 36 Stat. L. 369.

[13] Holmes' successors have been Van H. Manning (Aug. 25, 1915–May 31, 1920), Dr. F. G. Cottrell (June 2–Dec. 31, 1920), H. Foster Bain (May 10, 1921–June 30, 1925), Scott Turner (Nov. 16, 1925–Aug. 15, 1934), John W. Finch (Aug. 28, 1934–Mar. 20, 1940), Royd R. Sayers (June 18, 1940–July 13, 1947), James Boyd (Aug. 27, 1947–Oct. 16, 1951), John J. Forbes (Nov. 15, 1951–Nov. 30, 1955), Marling J. Ankeny (July 20, 1956–Dec. 30, 1964), Walter R. Hibbard (Dec. 1, 1965–Apr. 1, 1968), John F. O'Leary (Oct. 10, 1968–Mar. 1, 1970), Elburt F. Osborn (Oct. 23, 1970–Sept. 23, 1973), Thomas V. Falkie (Mar. 28, 1974– —).

As defined in the Organic Act, the scope of the Bureau of Mines was extended into the technical processes of production and use, including mineral technology and metallurgy. In addition to these efforts and the testing of fuels and the investigation of mine explosions (which had been taken over from the USGS), the Bureau of Mines was authorized to investigate the methods of mining, including especially:

—the safety of miners, and the appliances best adapted to prevent accidents;
—the possible improvement of conditions under which mining operations were carried on;
—the treatment of ores [14] and other mineral substances;
—the use of explosives and electricity; and
—the prevention of accidents.

Before the Organic Act went into effect, it was modified in two ways: (1) The appointment of two inspectors of coal and other mines in the District of Alaska was authorized, and (2) the supervision of the inspection of structural materials was transferred to the National Bureau of Standards of the Department of Commerce and Labor.[15] In 1911, provision was made for tests and investigations, other than those performed for the Federal Government or a State government, to be performed on a fee basis subject to authorization by the Interior Secretary.[16]

The Bureau's scope was extended in 1913 by an amendment, which completely supplanted the original Organic Act. In the new act, it was described as a bureau of "mining, metallurgy, and mineral technology," [17] with the following functions:

—to conduct inquiries and scientific and technologic investigations concerning mining, and the preparation, treatment, and utilization of mineral substances with a view to improving health conditions, and increasing safety, efficiency, economic development, and conserving resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries;
—to inquire into the economic conditions affecting these industries;
—to investigate explosives and peat;
—on behalf of the government to investigate the mineral fuels and unfinished mineral products belonging to or for the use of, the United States, with a view to their most efficient mining, preparation, treatment, and use; and
—to disseminate information concerning these subjects.

In 1915 Congress passed an act that authorized the establishment of 7 mine-safety stations and 10 mining experiment stations;[18] by 1921, the number of mining experiment stations had been increased to 13 and, in addition, 12 field offices had been established. (Fig. 1.)

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[14] Ore is a mineral or minerals, mixed with gangue (nonvaluable, or waste material), which can be recovered economically.
[15] 36 Stat. L., 703, 742, 743, 765.
[16] 36 Stat. L., 1363, 1419.
[17] 37 Stat. L., 681.
[18] 38 Stat. L., 959.

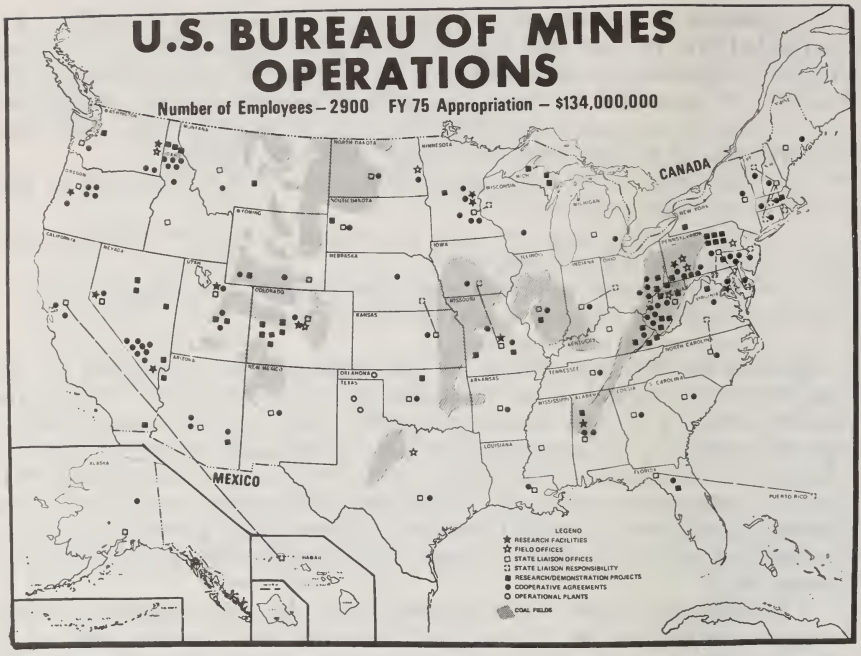

FIGURE 1.—Map showing location of research facilities of the Bureau of Mines.

To assure that the Bureau's activities would be devoted to the interest of the Nation and not that of any company or group of companies, the Organic Act of 1913 specifically forbids the Director and all employees (1) from having any financial interest in any mine or the products of any mine under investigation, (2) from accepting employment from any private party for services in connection with the investigation of any mine or mineral property, and (3) from issuing any report on the valuation or managment of any mine or other mineral property.

The wisdom of this prohibition and the faithfulness with which it has been observed are evidenced by the willingness of concerns in all branches of the mineral industries to impart company secrets to the Bureau's engineers and scientists, knowing that the information will be held in confidence.[19]

Although the Bureau of Mines has always been primarily a scientific and technologic agency, at times regulatory duties have been given to it, such as licensing the wartime sale and use of nonmilitary explosives and the enforcing of precautions against coal-mine disasters.

As early as 1913 the Bureau was inspecting mines on Indian lands, and in 1914 it was authorized [20] to investigate the extensive coal deposits on Alaskan public lands for the purpose of dividing them into coal-mining leases. It also drafted regulations (to minimize waste and maximize safety) for the operation of those leases and, after the Mineral Leasing Act of 1920 was enacted, the Bureau drew up similar regulations for the production of coal, oil shale, petroleum, natural gas, sodium, and phosphate on all Federal lands. For a while, the Bureau of Mines also measured the mineral output from these leases,

[19] USBM Manuscript Report, 1954, p. 40.
[20] Public Law 63-216.

certifying the amount of royalties due the Federal Government, and administered all operations on the naval petroleum reserves.[21]

From its beginning, the Bureau's field of research has included all mineral industries—except for the first year when the language of the Appropriation Act restricted its activities almost completely to coal and oil. One of the first steps taken to further this early emphasis on coal research, was to open the experimental coal mine at Bruceton, Pa.

Early studies on coal

In its early years the Bureau's coal work consisted mainly of fuel testing and mine-accident investigations, and it shortly took leadership in these fields. Special attention was given to the fuels that were little-used in the United States—peat, lignite, and subbituminous coal.

In 1910, as coal furnished 85 percent of the U.S. energy that was derived from mineral fuels, the Bureau began studies to increase the efficiency of coal combustion—especially at the coal-testing plant in Pittsburgh. In 1921 the Bureau began studies on the direct combustion of pulverized coal (at a Milwaukee powerplant, in connection with industry), and continued them at the Pittsburgh experimental station.

The first bulletin of the Bureau of Mines, issued in 1910, gave the results of carbonizing several different kinds of coal; this, coupled with other laboratory studies, provided the fundamental information needed for the development of byproduct coking in the United States. By 1935 this technique was supplying 95 percent of U.S. coke production, thus eliminating the great waste of resources that accompanied the use of the old beehive ovens. The development of the byproduct coke oven (also called the chemical-recovery or slot-type oven) was further improved by the USBM–AGA [22] test for determining the gas-, coke-, and byproduct-making properties of U.S. coals.

Public interest in fuels, greatly stimulated by the work of the Bureau and its predecessors, was rewarded in the Bureau's early days by the development and standardization of testing and of methods for analyzing coal—in cooperation with the American Chemical Society and the American Society for Testing Materials.

The Bureau of Mines and the U.S. Geological Survey were American pioneers in developing new views on the origin of coal and the meaning of the banded structure of bituminous coal. The Bureau devised the Thiessen method of grinding sections of coal thin enough to permit microscopic examination of the coal through transmitted light. [23] This technique formed the basis for the Bureau's petrographic [24] analyses of coal, which are important in the classification of coal by rank. Research conducted at the Pittsburgh Experimental Station before World War I showed: (1) A continuous change in rank according to carbon, hydrogen, and oxygen, and (2) that the moisture content increases as the rank decreases; from this work came the concept of micropores in coals of low rank.

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[21] USBM Manuscript Report, 1954, p. 41.
[22] American Gas Association.
[23] Light that passes through the thin section from below, permitting the delicate coal structure to be seen through the microscope.
[24] A microscopic analysis of the physical properties and structure of rocks and rock materials.

Pioneer research on petroleum

The Bureau began in 1910 to analyze samples of crude oil and to test fuel oil in laboratories in Pittsburgh and San Francisco, respectively; both activities had been inherited from the technologic branch of the USGS. The Bureau shortly began field studies of oil and gas wastes, of sulfur compounds in petroleum, and of efficient extraction of liquids from natural gas.

Although the civil service classification of petroleum engineer had been established in 1912 and much technical literature had been published by the Bureau, "its biggest immediate task was convincing the oil industry of the value of research."[25] Accordingly, in 1913 the Bureau Director convened by invitation the first national gathering in the United States of oil people, in Pittsburgh. The Bureau's recent discoveries, coupled with the opening of the first commercial cracking[26] plant, made apparent the practical value of knowledge about the composition of crude oils. New studies were begun, to improve methods of both recovery and refining, with the limited Bureau funds forcing their engineering and scientific personnel to use the operations of the oil companies as their laboratories. Close cooperation with the industry developed, which continued throughout the Bureau's history as it worked on petroleum and natural gas.

Early investigations on safety

Soon after the opening of the Bureau's experimental coal mine at Bruceton, Pa., tests conducted there demonstrated conclusively that an explosion in a mine, in the absence of gas, could be caused by bituminous coal dust suspended in air. Previously this had been doubted by coal-mine operators and miners, and it still took many years and hundreds of demonstrations, and several horrible disasters, before they were convinced.[27]

In its early years the Bureau began investigations of mine illumination, which led to the development and use of electric cap lamps instead of open lights. The Bureau also began studies of the use of electricity in mines, from the dual standpoints of safety and efficiency; these studies took on increasing significance as mechanization in the mining industry increased.

The Bureau's study of explosives and explosions was first directed toward establishing standards for explosives; if they met the standards, explosives were classed as "permissible." Beginning with the slow-burning black blasting powder, these chemical analyses and the physical testing of explosives submitted by manufacturers for approval were rapidly expanded to include other explosives, for different types of blasting under a variety of conditions. One of the Bureau's early accomplishments in this field was the introduction of liquid oxygen explosives (LOX) in this country, for use in quarrying and open-pit mining. These studies were subsequently expanded to include fundamental research on the nature and phenomena of flame.

Smelter fumes and radium

The metallurgical work of the Bureau began in 1911, at the request of the Department of Justice when it was considering shutting down

[25] *USBM Manuscript Report*, 1954, p. 47.
[26] The process of breaking down hydrocarbons by heat and pressure, into lighter hydrocarbons of lower molecular weight; in this manner, gasoline is made from crude petroleum.
[27] *USBM Manuscript Report*, 1954, p. 48.

two smelters because sulfur fumes were killing vegetation on public land forests. The Bureau's researchers were ordered to solve two problems: (1) how to prevent damage to crops by smelter fumes, and (2) how to recover and use commercially valuable materials that were being wasted by the smelters. The Bureau arranged for the 2 accused smelters to begin detailed sampling, and it also investigated methods and conditions at 22 copper and lead smelters throughout the Nation.

The result was the installation of the first experimental electric smoke-treatment apparatus, and the construction of a plant for recovering sulfuric acid from smelter fumes.[28] A similar problem arose during the 1930's, when prevailing winds carried fumes from the smelters at Trail, British Columbia, to neighboring farms across the Columbia River and southward into the United States. When the U.S. farmers tried to collect damages through an International Commission, arrangements were made for the smelters to recover all of the sulfur that had been going up the stacks; this sulfur was then used for fertilizers and other sulfur products.[29]

In developing a method for extracting radium from carnotite[30] ores in Colorado and Utah, the Bureau achieved one of its most dramatic early successes. Uranium demand in the United States in 1912 had far exceeded the supply, and U.S. pitchblende[31] ore was being shipped overseas for treatment by a patented process which resulted in a prohibitive price of $140,000 per gram for the radium when extracted and shipped back to the United States. The Bureau, in cooperation with the National Radium Institute, tackled the problem at a newly established laboratory in Denver, and the resulting process made it possible both to treat the carnotite ore at home and to use great quantities of previously-discarded uranium-bearing material that had been too lean for economic recovery. The cost of radium in the United States was thus reduced to less than $40,000 per gram.

Experiment stations authorized

The Bureau's research activities required experiment stations, the first of which was established at Pittsburgh. In addition, several small clusters of investigators were at work in San Francisco (California), Salt Lake City (Utah), and Ithaca (New York), when the Congress passed The Foster Act in 1915[32]—authorizing 10 additional mining experiment stations and 7 additional mine-safety stations. New mining experiment stations were added annually for the next several years, resulting in the following list: (Figs. 2–8)

Pittsburgh, Pa.;
Berkeley, Calif. (transferred from San Francisco);
Salt Lake City, Utah;
Denver, Colo.;
Golden, Colo. (later moved to Reno, Nev.);

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[28] A method of recovering arsenic from smelter fumes proved so successful that the resulting improvements enabled the plants to produce so much arsenic that the market was completely satisfied. (*USBM Manuscript Report*, 1954, p. 50).

[29] *USBM Manuscript Report*, 1954, p. 50.

[30] Carnotite is a uranium oxide mineral, the principal source of the uranium that has been so important to the United States and other industrialized countries for the past 30–40 years.

[31] Pitchblende is a massive variety of uraninite (uranium oxide), which occurs in veins that carry sulfide minerals and a slight amount of radium.

[32] Public Law 63-283.

Minneapolis, Minn.;
Rolla, Mo.;
Tuscaloosa, Ala.;
Tucson, Ariz.;
Seattle, Wash.; and
New Brunswick, N.J. (later moved to College Park, Md.).

FIGURE 2.—Pittsburgh, Pa., Metallurgical Experiment Station.

FIGURE 3.—Salt Lake City, Utah Metallurgical Experiment Station.

FIGURE 4.—Reno, Nev., Metallurgical Experiment Station.

FIGURE 5.—Twin Cities, Minn., Metallurgical Experiment Station.

FIGURE 6.—Rolla, Mo., Metallurgical Experiment Station.

FIGURE 7.—Tuscaloosa, Ala., Metallurgical Experiment Station.

FIGURE 8.—College Park, Md., Metallurgical Experiment Station.

At each of these stations, metallurgical and mining research activities that were appropriate for that area were undertaken.

Establishment of new industries—molybdenum and potash

In its early years the Bureau helped pave the way for the establishment of a domestic molybdenum-mining industry. Its pioneering work included the development of methods of concentrating wulfenite,[33] molybdite[34] and other molybdenum ores, as well as studies on the use of molybdenum as a ferroalloy[35] metal; the outbreak of World War I in Europe in 1915 gave added impetus to this work.

When the U.S. supply of potash[36] from Germany was cut off during World War I, the Bureau conducted technological research that helped the U.S. potash industry recover this fertilizer mineral from sources such as cement-mill dust, greensand,[37] and brines from western salt lakes.

After the war, European potash again became available, at prices too low for U.S. producers to meet. As a result, under the Potash Exploration Act of 1926[38] the Bureau of Mines (in cooperation with the USGS), undertook an exploration program that discovered large reserves of polyhalite[39] in New Mexico and Texas. At the same time, laboratory studies by the Bureau developed processes for extracting potash from this complex mineral, resulting in the establishment of a U.S. industry on a sound economic basis. After 1930 the U.S. industry developed rapidly, so that during World War II it was able to supply the essential domestic needs for potash.

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[33] A mineral containing lead, molybdenum, and oxygen.
[34] A mineral containing molybdenum and oxygen.
[35] Ferro means iron-bearing.
[36] A chemical compound of the elements potassium and oxygen.
[37] Sand-size particles of the mineral glauconite (a silicate containing iron and potassium), which is common along today's beaches as well as older geologic deposits, inland.
[38] Public Law 69-424.
[39] A complex mineral with potassium, magnesium, and calcium.

Minerals for World War I

Problems of mineral supply arose with U.S. entry into World War I, and in July 1917, a War Materials Committee [40] was established to coordinate efforts to solve them. In addition, the Joint Information Board on Minerals and Derivatives was organized as a clearinghouse of information for all Federal agencies interested in minerals problems; the Bureau of Mines was included in the Board.

Until the end of hostilities, the Bureau helped mineral producers obtain priorities for transportation, fuel, and equipment; get roads built; obtain necessary labor; and solve mining and milling problems. In addition, it gave advice on mineral problems to agencies concerned with the conduct of the war.

The Bureau also worked intensively on the so-called war minerals, for which the United States depended mainly on imports—studying especially antimony, chromite, graphite, magnesite, manganese, mercury, mica, tungsten, and minerals of the platinum group. These studies included investigations of mineral deposits, problems of mining, milling, and mineral concentration; and metallurgical research.

Also, the Bureau cooperated with the War Department in investigating the synthetic production of nitrogen [41] and increasing the availability of pyrite [42] and native sulfur [43] for producing sulfuric acid. In addition, the Bureau studied the extraction of vanadium and uranium ores, for possible use in special steels.

Meanwhile, the Federal Government had been urging the maximum production of war minerals; when hostilities ended suddenly on November 11, 1918, many mine operators had not yet recovered their investment—and had little hope of doing so because they could not compete with higher-grade material that was again available from abroad. Thus in March 1919, the Congress passed the War Relief Claims Act,[44] which authorized the Secretary of the Interior to adjust certain financial losses that were being suffered by interests which had produced or attempted to produce chromium, manganese, pyrite, or tungsten in response to the Federal Government's urging during the war. Also, the Interior Secretary appointed a War Mineral Relief Commission, to review claims and advise him as to their disposition. The Bureau made examinations of properties and accounts of the claimants, and did administrative work for the Commission—which then made recommendations to the Secretary on more than 1,100 claims before it was disbanded in 1926.

War gas studies

The Bureau had studied poisonous and explosive mine gases from its beginning, and had investigated the use of rescue apparatus and masks, and methods of reviving people who had been overcome by bad air. The Bureau's gas investigations laboratory was the first in the United States that was devoted completely to research on gases, and included natural gas and other fuel gases, mine gases, and toxic or unbreathable gases that occur in metallurgical and other operations in the mineral industries.

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[40] Executive Order; the Committee included representatives of the Bureau of Mines, the USGS, the American Institute of Mining Engineers, the Mining and Metallurgical Society of America, and the Association of State Geologists.

[41] One of the fundamental materials for explosives.

[42] A mineral containing iron and sulfur.

[43] The other fundamental explosive material.

[44] Public Law 65-322.

Early in April 1917, the Bureau's offer to put its facilities for studying poisonous gases and gas masks at the disposal of the War Department was accepted; immediately, the Bureau undertook to develop gas masks, and began research on poisonous gases and other chemicals used in warfare—enlisting the cooperation of the Nation's universities and research institutions in the effort.

On July 1, 1917, the War Department provided funds for expansion of the Bureau's poison gas efforts, which heretofore had been financed from the Bureau's own funds. In August 1917, the manufacture of gas masks was transferred by Executive order to the Surgeon General's Office of the Army, with the Bureau continuing as a research organization that advised both the Army and Navy regarding gas masks and war gases. In September 1917, the Bureau established an experiment station in two rented buildings on the campus of American University, in Washington, D.C.; therein it worked on a number of other products in addition to gas masks and war gases, such as airplane bombs, signal lights, smoke screens, gas shells, gas bombs, and trench mortars, and flame throwers.[45]

After World War I, the Bureau developed highly efficient equipment for protection against mine and industrial gases and dusts—including gas masks that were effective against carbon monoxide for limited periods (which the Army gas mask was not), as well as various types of air- and oxygen-respirators for use in oxygen-deficient atmospheres.

Regulation of explosives in wartime

The Bureau was authorized by the Federal Explosives Act of October, 1917 [46] to regulate the manufacture, sale, and purchase of explosives in time of war, and issued more than 1 million licenses during the period 1917–18.[47]

Ventilation of vehicular tunnels

In 1919 the Bureau was asked to study the physiological effects of motor-vehicle exhaust gases in the confined space of a tunnel.[48] Field studies were carried out in Pittsburgh, and the toxicity of exhaust gases and the maximum safe concentration of carbon monoxide were determined by tests in the medical laboratories of Yale University.[49] At the Pittsburgh Experiment Station the Bureau also studied first-aid treatment methods for persons overcome by carbon monoxide in mines, in metallurgical plants, and in tunnels.

The Bureau next attacked the problem of ventilation, at the University of Illinois Experiment Station in Urbana, Ill., with those results being tested in a model tunnel in the Bureau's Experimental Coal Mine at Bruceton, Pennsylvania. The result of this program was the development for the Holland Tunnel under New York City of a system of ventilation "so satisfactory that it was adopted for similar tunnels in this country and abroad." [50]

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[45] The Bureau's war-gas investigations staff of 1,682 people (half military, half civilian) subsequently became the Research Division of the Chemical Warfare Service (later, the Army Chemical Corps).

[46] Public Law 65-68.

[47] During World War II, the same act was amended (Public Law 77-381), and the Bureau issued 760,000 licenses.

[48] In connection with plans to build the country's first long vehicular tunnel, under the Hudson River between New York City and New Jersey.

[49] These studies showed that existing methods of gas analysis were not accurate enough to determine small amounts of carbon monoxide in air when gasoline is present, so the Bureau developed a new method.

[50] USBM Manuscript Report, 1954, p. 59.

Properties of gases

One of the early investigations of the gas laboratory, shortly after the Bureau was created, was the complete analysis of samples of natural gas from all parts of the U.S. Accurate analytical methods were developed, the first time that such accurate analyses were made generally available. Also, as part of this study, determinations were made of the gasoline-vapor content of these gases. Later, in connection with industry, the Bureau worked out practical methods for recovering this gasoline—by compression and refrigeration of the gas, or by absorbing the gas in oil.

In 1923 the Bureau was asked to conduct an experimental study to determine whether the general use of tetraethyl lead in gasoline (to prevent motor knock) would cause a health hazard to the public. The investigation was carried out in cooperation with the U.S. Public Health Service and the General Motors Corp., and included chemists, physiologists, pharmacologists, and pathologist. As a result of two years of developing apparatus and experimentation with test animals, "the investigation indicated that no immediate or chronic increase in the public health hazard from automobile exhaust gases would be created by adding tetraethyl lead to gasoline. More than 25 years of experience in the use of leaded gasoline supports the conclusions resulting from this research." More recent studies indicate otherwise.[51]

Another spinoff from the Bureau's war-gas experience was the study of possible warning agents for manufactured gas. The AGA asked the Bureau to make a comprehensive study of substances that might be added to non-odorous fuel gases, in order to impart either an odor or an irritating action—so that asphyxiating or flammable gases which escape accidentally into rooms can be recognized. Hundreds of promising chemical substances were examined and measured, showing that odors do not awaken sleeping person but that nose and throat irritants do so. The cost of the irritants was about 20 times the cost of the odors, so the latter were adopted in practice. Nevertheless, many lives and much property have been saved by the general use of odor agents.

Electric brass furnace development

Waste of metal, expecially zinc, that was lost as fumes during the melting of brass and other nonferrous metals caused the Bureau to begin a research program to reduce these losses. Also, the health and accident hazards of the fuel-fired furnaces then in use provided an added incentive. As the electric furnace offered a promising solution to both conservation and safety problems, the Bureau attacked the problem in that twofold manner, with the cooperation of brass melters, electric furnace designers, and electric power companies. After a period of trial and error, in 1916 the commercial development and installation of electric brass furnaces began—and by 1919 this type of equipment was becoming established in the nonferrous metals industries. By 1922 the Bureau was able to issue a bulletin summarizing developments in its own experiment stations and in industry, in which it predicted that "the electric furnace bids fair to become the standard type for brass melting." [52]

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[51] Thus in the past decade or so the Bureau of Mines has had to restudy its earlier results, and has published a number of reports that present a different picture.

[52] Gillett, H. W. and E. L. Mack, Electric Brass Furnace Practice: *U.S. Bureau of Mines Bulletin 202*, 1922, p. xii.

B. PROGRAMS OF THE EARLY 1950'S [1]

Strategic and critical minerals [2]

In the early 1950's the Bureau of Mines was conducting numerous programs that were designed to sustain and increase the U.S. supply of mineral raw materials; these ranged from outlining deposits of strategic and critical minerals, through developing improved techniques for mining and ore dressing, to conducting both fundamental and applied research in the quest for new metallurgical processes. In addition, the USBM performed mineral economics studies and the collection of statistical data on mineral industry operations.

The investigation of marginal and submarginal deposits of strategic and critical minerals had been an important activity since passage of the Strategic Materials Act of 1939.[3] Under its authority, which was reiterated in the Stockpiling Act of 1946,[4] the Bureau cooperated with the U.S. Geological Survey in an attempt to block out reserves of ore that would form an underground stockpile, on which the Nation would draw in times of need; the USGS did the initial reconnaissance scouting and prospecting, followed by the Bureau's sampling and metallurgical testing needed to outline the deposit and determine its character.

After the United States entered World War II, in 1941, the program's objective was shifted to outlining deposits that could be developed immediately, by industry. In addition, its scope was broadened from the original seven commodities to include all metals and minerals that were on the strategic and critical list of the Munitions Board, as well as substitutes for them. After World War II the original objective was returned to, but the expanded list of commodities was retained.

During World War II, when the demand for metallic and nonmetallic [5] minerals was very high, private development and mining often followed immediately after the Bureau had outlined a deposit and made its results available to the public. Examples are: (1) tungsten in the Yellowpine Mining District of Idaho, which contributed substantially to the U.S. war effort by supplying more than 50 percent of U.S. demand; and (2) the huge San Manuel copper porphyry deposit in Arizona, where the Bureau outlined 110 million tons of ore that contained 0.77 percent (15 pounds per ton) of copper. In the latter case, further drilling by the mining company resulted in a tripling of the ore reserves; that mine was still producing, 30 years later.

Except during a major emergency such as World War II, the Bureau's mineral investigations program was not intended to duplicate the work normally done by mining companies; therefore, the Bureau focused its attention on marginal and submarginal deposits.[6]

This USBM–USGS program was suspended in 1951, when the Defense Minerals Administration (DMA) began a program of Federal financial assistance in order to stimulate exploration by private

[1] Derived largely from USBM Manuscript Report, 1954, p. 62–90.
[2] For list of strategic and critical minerals, see app. I.
[3] Public Law 76–117.
[4] Public Law 79–540.
[5] See app. II for groupings of metals and nonmetals.
[6] Most of these were so lean as to be uneconomic, or so complex as to be so difficult to treat for recovery of the metal or nonmetallic element sought, that they were unattractive for commercial exploration.

industry for strategic and critical minerals. The Bureau and the USGS provided mining engineers and geologists, respectively, to examine prospects and make recommendations regarding requests for which applications had been received. In 1951 this program was continued by the DMA's successor, the Defense Minerals Exploration Administration, which in 1958 was supplanted by a slightly different program under the Office of Mineral Exploration (OME) in the Department of the Interior. The OME has not stimulated minerals exploration as expected; rather, it has been largely a caretaker operation of managing outstanding loans, and in 1976 the program's funding was deleted by the Office of Management and Budget.[7]

Leadville drainage tunnel

Shortages of strategic metallic minerals during World War II caused the Bureau to undertake one of the most difficult jobs in its history—the Leadville, Colo., drainage tunnel. Leadville had been a fabulously rich mining district before most of its mines were forced to close in the middle 1920's because of recurring labor troubles and low prices for metals.[8] The pumps that had kept the mines free of underground water were shut down, and the abandoned mine workings were flooded.

During World War II, a USGS team had reported the Leadville Mining District as a favorable one for discovering and mining new reserves of lead, zinc, and manganese minerals, if its mines could be dewatered and rehabilitated. A drainage tunnel was preferred over pumping because it would provide continuous drainage, access for exploration and development and mining, and possibly cheaper mine haulage.

Accordingly, the Congress authorized the Bureau of Mines to construct a tunnel, and appropriated $1.4 million initially and $0.5 million later. The tunnel, conceived and planned by the Bureau, was constructed by private firms. Although tunnel work began late in 1943, it was suspended in 1945 when demand for metallic minerals declined at the end or World War II; the tunnel was resumed in 1950 after the outbreak of the Korean conflict, and was completed in February 1952 at a total cost of $2 million.[9]

The Leadville tunnel reopened parts of the mining district that had produced metallic minerals valued at more than $500 million through a period of 105 years.[10] In addition to draining mines whose floors were above the tunnel, it also lowered the pumping cost of mines below that level.

Furthermore, several good showings of metallic minerals were found during the construction of the tunnel and, within 6 months after its completion, exploration and development work was underway by private companies; under an agreement with the owners of the property penetrated by the tunnel, the Federal Government was to

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[7] The need for a far more complete inventory of the Nation's mineral reserves than now exists, particularly on the public lands, is recognized by the Interior Department and the Congress through current appropriations for such investigations by the Bureau and the USGS. (See following chapter.)

[8] Henderson, Charles W. "Production, History, and Mine Developments," pp. 109–144, in Emmons, S. F., J. D. Irving, and G. F. Loughlin, "Geology and Ore Deposits of the Leadville Mining District, Colorado": U.S. Geol. Survey, Prof. Paper 148, 1927 (esp. pp. 109–144).

[9] Much of the tunnel, which is 2 miles long, was driven through wet, highly fractured ground that was very difficult to penetrate, and required much timbering to hold back the loose wall- and roof-rock.

[10] The Leadville Mining District, like many in the western United States, had had several periods of mining, each characterized by principal production of different metals: Leadville's 4 periods were gold (1860–75), silver-lead (1876–1907), zinc (1909–25), and mixed lead and zinc (1935–57), with production value totaling $507 million. (Tweto, Ogden, "Leadville District, Colorado," pp. 681–705 in Ridge, John H. ed., "Ore Deposits of the United States, 1933–67": NY, NY, AIME, 1,880 pp.)

collect royalties on minerals whose access, production, and sale resulted directly from the drainage project. Tunnel-maintenance costs were expected to be nominal.[11]

World War II minerals security work

Upon the entry of the United States into World War II in 1941, the need for maintaining and expanding industrial production in light of the possibility of sabotage became a real concern. As an extension of the Bureau's inspection of mines, mills, smelters, and refineries, its personnel, under the direction of the War Department and the Office of Civilian Defense, attempted to insure that proper precautions were being taken against the possibility of work interruption by enemy agents. By April 1944 a total of 79 Bureau engineers had made security investigations of more than 2,900 mineral facilities as part of this effort.

Mining research

Mining studies have constituted an important part of the Bureau's efforts, ranging from investigations of proposed mining methods, techniques, and equipment in operating mines and quarries, to fundamental research on rock breakage by explosives and on the nature of rock stresses on underground mine openings and structures. This mining research is carried on in commercial mines, in experimental mine openings, and in Bureau laboratories and those of cooperating institutions.

Bureau reports, which deal with many phases of mining operations such as shaft sinking and the hoisting of material to the surface, have led to reduced costs at many mines.

The Bureau has employed both physical models and mathematical studies to learn more about the forces exerted on mine openings by the enclosing rock. One dramatic result has been the development of a microseismic method for detecting stress in rock.[12] This is particularly important in providing advance warning of impending roof falls and rock bursts in metallic mines, and of bumps in coal mines.

In addition to the foregoing example of fundamental research, since 1922 the Bureau has investigated the breaking of ore and coal by explosives. Since millisecond-delay detonators were introduced in 1950, the Bureau has studied the advantage of firing multiple blasting shots both simultaneously and at short intervals—in order to determine the best results under the various conditions that are common in mining.

The Bureau expected that this work would eventually result in the ability to calculate in advance the most effective and economical blasting pattern and practices that will give the maximum break of drill rounds [13] for a desired degree of fragmentation.

The experimental coal mine at Bruceton, mentioned earlier, was supplemented by two others—at Mount Weather, Va., and Rifle, Colo., which were opened in 1936 and 1945, respectively. At Mount Weather, drilling and blasting problems in narrow headings in hard rock, and research on diamond drilling were studied. Research on

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[11] USBM Manuscript Report, 1954, p. 68. The costs were nominal, while the tunnel was being maintained. However, the Leadville Mining District succumbed to economic forces and the exhaustion of higher grade ore and was abandoned again, in 1957. The Leadville tunnel in the ensuing 20 years of nonmaintenance has suffered the normal woes of cave-ins and collapse, so that it is no longer serviceable.

[12] Microseisms are minute shocks that are recorded by geophones (sensitive microphones inserted in holes drilled in the rock), which are produced when rocks are under stress; the intensity and frequency of these microshocks, which are too faint for humans to hear or feel, as read from the recorded chart tells when the rock strain becomes dangerous.

[13] A round (or set) of holes is drilled in the rock, then loaded with explosives and fired in one blast (or pull).

diamond bits since World War II resulted in the development of a method of setting the diamonds in the bit so that drilling speed is increased and the life of the diamonds is prolonged.[14]

The experimental mine at Rifle was established as a result of the Synthetic Liquid Fuels Act of 1944, to determine an efficient method of mining a 73-foot thickness of oil shale in western Colorado. Practices and equipment developed there have also been used elsewhere, for mining other materials that occur similarly in thick, horizontal rock strata.

The Bureau conducted a large amount of research on coal-mining techniques and methods in the years following World War II, spurred by the growing consumption of coal as coke for steelmaking, and by the economic problems faced by both the bituminous coal and anthracite producers.

Since World War II the Bureau of Mines was instrumental in introducing the practice of roof-bolting in coal mines, and this practice spread rapidly to metal mines. Although this work was done as part of a program to reduce accidents from roof-falls, it also was found to permit greater mobility of mining equipment and thus reduce overall mining costs.

In the early fifties the Bureau recognized the need for studies of more efficient and economical methods of mining ores that occur in narrow veins. Although numerous machines had been brought into use that can reduce costs and increase production per man-shift in larger mines and those having more widely distributed ore, smaller mines and those that work narrow veins still relied in the early fifties upon arduous and relatively costly hand methods. The Bureau recognized the need for developing compact and inexpensive machines that could be used in such mines.[15]

Explosions and explosives

In its research on explosives, the Bureau has designed specialized equipment for testing their strength and sensitivity. In the experimental coal mine at Bruceton, under controlled atmospheres, tests showed the amount of stemming and the top weight of charge that would give adequate protection against ignition of mine gas or coal dust. Also, the roof effects of different kinds of multiple blasting were determined.

The Bureau's work on explosives was put to considerable use during World War II, in cooperation with the National Defense Research Committee in an extensive and fundamental research program on explosives and propellants. Much of this work was continued after the war, in cooperation with various branches of the armed services.

Research on rock-dusting, to prevent the spread of a coal-dust explosion, has been a major effort of the Bureau, to avoid the repetition of the numerous mine disasters in coal mines. Numerous other industrial dusts are explosive also—such as grain and cornstarch, and

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[14] In the 1950's, such industrial diamonds were not only expensive but also in very short supply.

[15] Although some progress has been made over the ensuing 20 years, in 1975 this lack of a more economical and efficient mining method for mines with narrow veins remains as one of the critical mining research problems; it has been cited as the principal reason for the shutting down on Oct. 31, 1975, of the huge Butte, Mont., copper mine (Senator Lee Metcalf, Proposed Closure of Underground Copper Mines: *Congressional Record,* Dec. 20, 1974, pp. S22564–S22565).

metallic dusts such as aluminum. It was discovered that suitable blower systems and other ventilating devices can remove the dusts harmlessly.

In response to a number of operating-room explosions, these investigations were extended into the hospital, as the Bureau studied the ignition hazard of static-electricity accumulation in operating and delivery rooms where anesthetics are administered. The Bureau was able to define and describe the hazards, and make practical recommendations to overcome them.

A related area of fundamental research by the Bureau, on the nature and characteristics of flame, has been useful not only in preventing mine disasters but also for preventing explosions aboard airplanes and submarines, in homes and hospitals, and in numerous kinds of plants. Furthermore, this work has provided much useful data in the design of jet engines.

Metallurgical research

The Bureau has studied every phase of metallurgy, from mineral dressing to preparing metals for fabrication, and has performed such fundamental research as determining the thermodynamics of metals. Some of its metallurgical work was done in cooperation with other Federal agencies, universities and technical schools, private research foundations, and industrial concerns.

The purpose of the Bureau's metallurgical investigations has been to increase the mineral resources that were available to the Nation, through learning how to recover, separate, and use more economically and efficiently the minerals contained in the ores.

The three main subdivisions of metallurgy are: (1) mineral dressing, (2) extractive metallurgy, and (3) physical metallurgy. Their characteristics are as follows:

—*Mineral dressing.*—Physical extraction or concentration of minerals from the rock matrix as it comes from the mine;

—*Extractive metallurgy.*—Extracting of pure metals from their ores as mined, or from concentrates; and

—*Physical metallurgy.*—Takes the pure metals that are prepared by the extractive metallurgist, and mixes or alloys them so as to obtain better properties for fabrication—this involves the field of manufacturing and, in contrast to mineral dressing or extractive metallurgy, normally is performed some distance from the mines and mills. (The Bureau does less research on physical metallurgy than on the other two.)

Mineral Dressing [16] has several purposes:

1. To reduce transportation costs by discarding as much waste material (gangue) as possible from an ore before shipping;

2. To provide a suitable feedstock for modern furnaces (which cannot handle large quantities of waste rock economically);

3. To make a product that will satisfy industrial specifications; and in some cases

4. To produce concentrations of several elements from the same ore, each containing as little of the others as possible.

Mineral dressing employs a number of techniques, such as jigging and tabling (using differences in specific gravity), froth flotation (using

[16] Also called "concentration" or "beneficiation."

differences in affinity for chemical reagents), and magnetic separation. Often, these separation processes include an intermediate step called "classification," in which the pulverized ore is separated into sands and slimes by specific gravity. Both sands and slimes may contain valuable minerals, but they require different treatment in order to recover such products.

The Bureau's mineral-dressing research is focused on the more complex beneficiation problems, which industry generally is less willing to undertake. An example is the huge but low-grade manganese deposit in Aroostook County, Maine—which had been outlined as part of the Bureau's mineral-exploration program. The Bureau's mineral-dressing research attempted to discover a way to separate the manganese from the silica—the latter being unacceptable in the making of ferro-alloy metals. To solve this problem, so that the Aroostook manganese would be acceptable to the steel industry, was expected to require the development of an entirely new ore-dressing technique.

Another challenge to mineral-dressing metallurgists was presented by pegmatite, a very coarse-grained igneous [17] rock that commonly contains a wide range of valuable minerals such as beryl, feldspar, quartz, and mica—and may also contain minerals with tantalum, columbium, tin, and lithium. With techniques available in the early fifties, only a few of these minerals and elements could be recovered economically from pegmatites.

Extractive Metallurgy, which separates the pure metal from other metals and materials in concentrates, involves a number of treatment methods—such as roasting, smelting, refining, or combinations of those three, plus leaching. These processes usually involve chemical changes, some of which are extremely complex, and are usually performed far from the mine—either at central smelters and refineries that are easily accessible to potential markets or at integrated plants that subsequently form the metal into shapes such as rods, bars, plates, or wires.

Extractive Metallurgy has at least two general subdivisions, hydrometallurgy and pyrometallurgy. Hydrometallurgy, a process in which liquids are used to separate the minerals chemically, has become the object of much research in the past few decades. First used in the U.S. to recover gold and silver from ores for which other concentrating processes were found to be inefficient, it was later applied to copper. By passing mine water that contained dissolved copper over and through scrap iron, cement copper was recovered.[18] Hydrometallurgy was extended by 1914 to the recovery of zinc; today, it is the most important method for extracting that metal.

The Bureau's metallurgical work in the 1950's was focused on specific commodities that are of long-term importance to the United States, or that present difficulties to industry in handling them. For many years the ferrous metals and alloys received increased atten-

[17] Igneous rocks are formed at depth in the earth's crust by heat and pressure, and form the cores of most mountain ranges; igneous rocks in former mountain ranges, which have been reduced by erosion to relatively flat surfaces that have since been buried by layers of sedimentary rocks, underlie much of the United States at depth.

[18] This process has been modified so that by applying acids to low-grade copper ores, the acid-leaches result in, first, low-grade cement copper and, later, high-grade electrolytic copper.

tion—especially manganese.[19] The Bureau's metallurgical programs resulted in the development of techniques for producing nearly pure manganese by electrolytic methods—although its relatively high cost restricts it to the production of special-purpose steels. Private industry has continued the work of the Bureau.

In the early 1950's the Bureau was conducting laboratory research and pilot plant studies to produce ferromanganese from several large, low-grade U.S. deposits and from slag from open-hearth steel furnaces, a waste material. The low-grade ores—from deposits at Artillery Peak, Ariz. and the Cuyuna Range, Minn.—were investigated in Bureau laboratories in Salt Lake City and Reno, and in Minneapolis, respectively. The slag was studied at Pittsburgh and College Park, in cooperation with the American Iron and Steel Institute.

Titanium, the fourth most abundant metallic structural element in the earth's crust (after aluminum, iron, and magnesium) had not been used as a metal [20] until the early 1950's, because impurities in the supposedly pure metal made it too brittle for a structural material.

In the early 1900's, processes had been discovered which produced nearly pure titanium metal—on a laboratory scale. This product, which was not only ductile but also had high strength, light weight, and remarkable corrosion resistance, could not be produced in any quantity, however. Therefore, in 1943, the Bureau began an intensive effort to device a method for producing pure titanium metal in large quantity; [21] actually, from 1939 to 1941 the Bureau had produced a good grade of titanium metal by an electrolytic process, but the method was both difficult and expensive.

After examining several processes that had been reported, the Bureau chose the one that had been developed by Dr. Wilhelm J. Kroll of Luxembourg. The Kroll process involved the reduction of titanium tetrachloride with molten magnesium in an inert atmosphere—usually helium. After successful laboratory tests in the Bureau's Salt Lake City facility, in consultation with Dr. Kroll (who had fled the Nazis and was in the United States), the process was simplified and the scale of operations had increased so that, by 1944, pilot

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[19] Steel, the foundation of an industrialized Nation, requires 14 pounds of manganese per ton. (There is no economic substitute for manganese in removing oxygen and sulfur from the melt.) Because U.S. deposits are too low-grade, the Nation has imported 10 percent or more of its annual requirements for many years. The sinking of numerous ships that were bringing manganese to the United States during World War II alerted the Nation to the peril of such complete reliance on foreign sources for an essential material that was required in large volume. Thus, since 1941 the Bureau has undertaken a number of metallurgical investigations in an effort to bring about greater self-sufficiency in manganese.

[20] A titanium ore, rutile (titanium oxide) was used in the early 1950's for welding rod coating; ferro-titanium was used as an alloying element; and titanium dioxide (the whitest known pigment) was being used increasingly in paints, enamels, ceramics, and dyes.

[21] World War II had brought almost unlimited requirements for light, strong metals—and titanium offered many advantages.

plant operations were begun at the Bureau's Boulder City, Nev., facility (fig. 9).

FIGURE 9.—Boulder City, Nev., metallurgical experiment station.

Using great care to prevent contamination by nitrogen and oxygen, the plant began turning out larger and larger batches of titanium metal from sponge, so that by 1947 the reactor had been enlarged to yield 200-pound batches of sponge, and metal production had risen to 800 pounds per week. Titanium's useful characteristics had attracted much interest, especially by the armed forces, and in 1948 the first production of ductile titanium by a commercial company was begun.

Closely related to the work on titanium, and holding equal promise, was the development by the Bureau of two other new and valuable metals—ductile zirconium and hafnium. Zirconium and hafnium ores (zircon and baddeleyite) are relatively abundant,[22] although the metals were classed as rare because isolating them had been both difficult and expensive.

Zirconium belongs to the same chemical family and has properties similar to those of titanium and, following the Bureau's adaptation of the Kroll magnesium-reduction process in experiments at its Albany, Oreg., laboratory (fig. 10) beginning in 1945, the Bureau produced most of the Nation's supply of metallic zirconium, nearly all of which was used by the Atomic Energy Commission in atomic-power structures. Private industry took over an increasing proportion of the production of zirconium thereafter.

[22] Zircon reserves are present in beach sands in Florida, California, and Oregon, and in stream-deposited sands in Idaho. Brazil is the main commercial source of baddeleyite.

FIGURE 10.—Albany, Oreg., Metallurgical Experiment Station.

Nearly all zirconium contains hafnium, which was at first thought to be deleterious. Accordingly, the Bureau developed a method for separating zirconium from hafnium and for recovering it as a by-product. The AEC found hafnium useful in its work, also. As with zirconium, private industry took over more of the production of zirconium and hafnium, so the Bureau turned its attention to expanded research on their properties and on those of their alloys.

Greater production and lower prices led to zirconium's use by the chemical industry in reagent containers and utensils, where it substituted for tantalum and thus released that strategic metal (which was in short supply) for other uses. Zirconium can also be substituted for manganese in steelmaking, and for tungsten in electric light bulb filaments and electronic tube parts. Also, since human-body fluids were thought not to affect it, zirconium was able to find wide use in surgery.[23]

Much of the Bureau's metallurgical work in the early 1950's was aimed at developing economic methods of smelting complex ores, to recover as many of their metals as possible. For example, low-grade deposits of nickel, chromium, and iron in the Pacific Northwest were being investigated because the United States depended on imports for the first two of them. Another metallurgical program in the Pacific Northwest during the early 1950's was designed to recover fluorine and vanadium, two strategic elements that were being lost in the

[23] Recently, health and safety questions have been raised about the use of zirconium and/or its derivatives as a super drying agent in deodorants, which are widely used by the public.

processing of phosphate ores in Idaho, Montana, Wyoming, and Utah.[24]

Strategic nonmetallic minerals were the subject of much USBM research in the early 1950's, as shown in the list below:

—obtaining sulfur economically from pyrite deposits, from hydrogen sulfide in "sour" natural gas, and from various industrial fumes;[25]

—using domestic graphite deposits when World War II threatened to interrupt U.S. imports of flake graphite;

—producing strategic grades of mica and asbestos synthetically from domestic raw materials;

—producing certain types of refractories from domestic raw materials such as clays, thus freeing the United States from dependence upon imported kyanite;

—obtaining a domestic replacement for the strategic block talc (which involves the building of blocks of talc powder by using binders, pressure, and heat); and

—by producing better lightweight concrete aggregate, partly to reduce the amount of steel required in building frames and in concrete reinforcing.

Some of the foregoing experiments by the Bureau were successful and the materials were later produced commercially.

Fuels

A major responsibility of the Bureau, until the establishment of the Energy Research and Development Administration in October 1974, was research on the three common mineral fuels—coal, petroleum and natural gas—together with a potentially fourth one, oil shale.

The Bureau's studies were both immediate and long-range—the former emphasizing special-purpose fuels such as high-grade coking *coal*, and petroleum products. Longer range investigations were aimed at (1) greater use of the Nation's extensive deposits of lignite and subbituminous coal reserves, which in the 1950's were relatively untouched, (2) more efficient and economic methods to mine and use Pennsylvania anthracite, and (3) large quantity production of synthetic liquid fuels from coal and oil shale.

In addition, the Bureau was the only civilian agency of the Federal Government that was studying explosions and explosion hazards of industrial dusts, fumes, and gases.

In response to the Nation's need for coal during World War II, the Bureau:

1—Conducted core drilling in Utah, New Mexico, Colorado, and Wyoming, to determine the quality and amount of coals present;

2—Conducted pilot-scale laboratory tests which showed that these coals, together with others from Oklahoma, Arkansas, and Washington, would yield coke for steel production in the West;

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[24] With a resulting hazard to the environment, the National Environmental Policy Act of 1969 finally focused national attention on the air pollution aspects of such mineral processing activities.

[25] Sulfur, which has experineced a feast-or-famine history in the United States since World War II, is now not so strategic because of the easier U.S. domestic supply situation, owing to increased production beginning in 1968; reserves both in the United States and abroad are huge.

3—Provided beehive coke operations in the Appalachian coal fields with technical data needed to produce better grade coke of more uniform quality, by sending a mobile laboratory into that area; and

4—Discovered ways to prevent the deterioration of coking properties of coal that was stored by coking plants in order to maintain steady production, and to avoid spontaneous combustion.

Because of the shortage of petroleum and its products during World War II, the more abundant solid fuels acquired increased importance as feedstock for electric power and industrial heat. The Bureau played a leading role in the National Fuel Efficiency program, which was organized to assist coal users both in the efficient operation of other fuel-burning equipment and in rehabilitating and modernizing their antiquated equipment; this nationwide effort was achieved with the voluntary help of several thousand technical experts. In addition, the Bureau provided information on the conversion of fuel-burning equipment from oil to coal and, in cooperation with an oil company, developed a method for making a colloidal mixture of pulverized coal and oil that could be used in large oil-burning units.

The Bureau has placed much of its fuel effort on coal because it constitutes the Nation's long-term reserve of energy-producing fuel, and because the coal industry until recent years has been made up predominantly of smaller companies with no research divisions.

The Bureau's coal-research program has included fundamental studies of coal chemistry and coal composition; technological investigations of all phases of coal extraction, preparation, and use; together with economic and statistical studies. In addition to its own laboratories and pilot-plants and the Experimental Coal Mine at Bruceton (Pennsylvania), the Bureau has enlisted the cooperation of coal-mining companies and private research organizations.

Major thrusts of the Bureau's coal research programs have been:

1—Increasing the recovery of coal that is mined underground, greater than 1950's average of 50 percent;

2—Developing and improving mine mechanization so that it will result in more efficient and economical production;

3—Assisting in rehabilitating the European coal-mining industry, both in connection with U.S. occupation of West Germany and in connection with U.S. economic assistance programs; [25]

4—Improving mechanical preparation of both run-of-mine bituminous coal and of low-grade coals; this includes washing methods of upgrading, such as kerosene flotation, and the removal of chemical impurities;

5—Inventorying U.S. mineable reserves of coking coal, on a county basis, followed by sampling each accessible coal bed for its preparation characteristics—to determine the upgrading needed to meet metallurgical standards and the complexity of

[25] The Bureau, which had observed coal planers being used in Germany in 1945, tearing coal from long-wall faces continuously and loading it onto conveyors, arranged for an improved model to be imported in 1949 for testing in a West Virginia mine; several U.S. coal-mining companies ordered coal planers upon learning of the favorable productivity and percent-recovery by the Bureau's test; this technique is being used today in U.S. coal mines where conditions are favorable.

this upgrading, followed by determining the carbonization characteristics [27] of the coal;

6—Collection and maintenance of the world's most complete file of coal analyses—to enable the Federal Government to purchase coal on the basis of rigid specifications and to help purchasers who may wish to bid on Government contracts.

7—Development of new techniques for production and use of Pennsylvania anthracite, through the Bureau's Anthracite Research Laboratory [28] at Schuylkill Haven (Pennsylvania), concentrating principally on more efficient, more economical, and less wasteful mining methods.[29]

8—Carrying out a 5-year engineering study of the mine-water [30] problem which in the early 1950's threatened to cut short the life of the Pennsylvania anthracite industry, resulting in a report to the Congress (as well as several technical reports) that recommended the construction of a drainage system [31] for the coal mines in which the Federal Government, the Commonwealth of Pennsylvania, and the anthracite operators would cooperate;

9—Gasification of anthracite to produce synthetic liquid fuels, use of anthracite as blast-furnace fuel for extracting manganese from open-hearth steel-furnace slag, and combustion studies of anthracite for domestic and industrial use; [32]

10—Utilization of very fine anthracite that is recovered from culm [33] piles and river bottoms;

11—Techniques for preparation, transportation, storage, and utilization of subbituminous coal and lignite in the West and Southwest,[34] using the Bureau's lignite research laboratory in Grand Forks, N. Dak.; [35] and

12—Development of methods for drying lignite (which has a high moisture content) and for storing it so as to avoid spontaneous combustion (which, despite its moisture content, is a significant hazard because of the ease with which oxygen can react with it).[36]

The Bureau still played an important role in *petroleum and natural gas* research in the early 1950's. Its purposes were twofold: (1) to increase the recovery of petroleum and natural gas from known deposits (estimated at 50 percent and 30 percent, respectively), and (2) to increase the efficiency of utilization of petroleum and natural gas and their products. The Bureau's scientific and technologic re-

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[27] Carbonization characteristics are important because a coal charge that expands too much could damage or ruin a modern slot-type coke oven. The Bureau had learned that the blending of coals with different carbonization characteristics can solve this problem.

[28] Public Law 77-812.

[29] Problems include: (1) the inexpensive recovery of mine pillars from the thick, flat coal beds in the Northern Field, without endangering structure and people at the surface above, flooding the mines, or causing collapse that would make other coal beds in the 12-bed series unmineable; (2) mining the thick and thin, steeply-dipping coal occurring in most of the other fields of the district, and (3) design and introduction of light-weight shearing machines and shaker scraper-loaders that are now cumbersome and expensive.

[30] Public Law 84-162.

[31] The mine-water problem has caused some mines to be abandoned, and threatens others; major disasters have been caused in the anthracite region by sudden inrush of water and mud into mine workings.

[32] A Research Advisory Committee of anthracite mining industry, mine workers, and the public of the anthracite region assists the Bureau in selecting research projects. (Secretary's Exec. Order)

[33] Miner's term for impure anthracite and carbonaceous shale.

[34] Public Law 80-454. A method for producing char and tar by heating subbituminous coal and lignite was developed, the former being used for boiler fuel and the latter as a source of chemicals; the Texas Power & Light Co. adopted the method using local lignite to supply electricity for an aluminum plant at Rockdale, Tex.

[35] Davis, Joseph D. and D. A. Reynolds, Spontaneous heating of coal: *USBM Technical Paper* 409, 1923, p. 16, 40-65 and fig. 9.

[36] Public Law 80-454. Improvements in a process of experimental gasification of North Dakota lignite were being sought; the resulting gas would be used (1) for reducing of Minnesota iron ore, (2) for producing synthetic liquid fuels, and (3) as utility-distributed gas for domestic and industrial fuel.

search fell into five major areas: (1) primary production, (2) secondary recovery, (3) transportation and storage, (4) chemistry and refining, and (5) thermodynamics of hydrocarbons [37] and their derivatives.

In addition, the Bureau was conducting studies of petroleum economics in the early 1950's.

Primary production studies included (1) detailed engineering investigations of individual fields, and (2) studies of the physical and chemical characteristics of reservoir rocks and fluids.

Secondary recovery [38] was recognized more than 25 years ago in the United States as being necessary to maintain the increasing supply needed to satisfy the growing U.S. demand for oil. Bureau studies attempted to (1) design improved injection methods, (2) help operators solve their secondary-recovery problems, and (3) increase the knowledge of the capillary forces that restrict the flow of oil from porous rocks.[39]

Secondary recovery problems that were being pursued by Bureau petroleum engineers, scientists, and technologists were:

1—"Conditioning" (chemically treating) the injection water;

2—Selectively plugging the "thief sands";[40]

3—Locating old and improperly abandoned [41] wells;

4—Preventing or minimizing the corrosion of metals by gases that are contained in the injection water; and

5—Shooting of producing and injection wells by explosives, to open up fractures so the fluids will flow more freely.

The Bureau's research on petroleum chemistry and refining was focused on developing new products to serve new uses.[42] Analyses of both domestic and foreign crude oils was a necessary first (and continuing) step, and the Bureau-developed analytical method became used in petroleum laboratories all over the world.

Diesel engines used in transportation are particularly sensitive to fuel quality, and inferior combustion characteristics and the deterioration of diesel fuels in storage have received much attention by the Bureau, both in its own laboratories and in the field.[43]

The Bureau, in cooperation with the American Petroleum Institute, was studying the problem of sulfur in petroleum—one that has

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[37] Hydrocarbon—a compound that contains only the two elements, hydrogen and carbon.
Petroleum—naturally occurring material composed mainly of mixtures of hydrocarbons, with or without other nonmetallic elements such as sulfur, oxygen, nitrogen, etc.
Oil—used interchangeably with petroleum.

[38] The injection of gas, air, or water into the producing formation, used when the natural reservoir pressure has diminished to the point that it can no longer move the oil to the well-pipe fast enough for a profitable operation.

[39] In the early 1950's, the best secondary-recovery methods still were leaving 50–65% of the original oil in the ground in many fields. In the past 20 years this record has been improved somewhat, and the 30–40% still left in the ground is being attacked by other, more sophisticated methods.

[40] Highly permeable sands that attract the flow of the injected fluid, causing it to by-pass the oil-producing formation.

[41] Nearly all States now have laws and regulations requiring the sealing of oil and gas wells when they are abandoned—especially States that are members of the Interstate Oil Compact Commission; however, even today the successful monitoring of all operations is not possible, and in earlier years thousands of wells were abandoned in a manner that would not be acceptable today.

[42] In the early 1900's, kerosene for lighting was the principal petroleum product. In 1917, gasoline for motors supplanted kerosene and, as engine-compression ratios increased, higher-octane gasoline was demanded. The use of fuel oil for heating and manufacture of steam increased. The rapid growth of diesel engines since World War II, coupled with the shift from piston to jet engines in military (and later, commercial) aircraft, required new and carefully fashioned fuels so that from 1942-45 the consumption of kerosene distillate and residual fuel oils exceeded that of gasoline by volume, and it did so again, beginning in 1947.

[43] One of the Bureau's new research devices was a constant-volume combustion "bomb." This permits tests to be carried out under completely controlled conditions of temperature and pressure, and gives a much clearer picture of the factors involved in combustion.

plagued the oil industry from its earliest days and has become even more significant in the past 20 years because of the increased use of crude oils with a high sulfur content and the consequent air-pollution problems that result.

Also in cooperation with the API, in the early 1950's the Bureau was making a number of periodic engine-fuel surveys (of motor gasoline, aviation gasoline and jet fuels, and diesel fuel oils). The results of these surveys were used by the American Society for Testing Materials in setting minimum octane numbers for its motor-gasoline specifications, and by the automotive industry in designing engines adapted to available fuels.

Looking toward greater utilization of U.S. petroleum resources, the Bureau was studying the large reserves of "black oils" in the Rocky Mountain region, which presented a challenge to petroleum chemistry and refining. High in sulfur, asphaltic and with high specific gravity, these oils were difficult to refine to produce the high-grade products by methods then in use. These refining problems were so difficult that some of these large reserves were not being used, and others were only marginal economically in the market of the early 1950's.

The Bureau's economic and statistical studies included the total petroleum and natural gas industries. Statistics were regularly compiled and published for production, refining, transportation, inventories, and consumption, and the Bureau also maintained current information on production and refinery capacity and on prices of the principal petroleum products throughout the world.

The Bureau of Mines was the world's only large-scale producer of *helium* until 1961. Since 1918 helium had been extracted from natural gas at plants in Texas, and later from plants in Kansas, New Mexico, and Oklahoma. In the later 1950's, increasing demand and diminishing helium reserves led to passage of the Helium Act of 1960, which added two new dimensions to the Bureau's helium program: (1) It provided authority for the Bureau to enter into contracts for the purchase of helium for conservation purposes; and (2) it encouraged private enterprise in the development and distribution of supplies of helium.[44]

Because helium is nonflammable, the U.S. Armed Forces in 1917 wished to use it for inflating lighter-than-air craft. The Bureau began research that year, and in 1925 took over the Navy's large-scale extraction of helium from natural gas (which had been underway since 1921); the Bureau of Mines has been deeply involved with the Nation's helium supplies ever since.

With the cooperation of the oil and gas industry, since 1917 the Bureau has continuously looked for sources of helium by obtaining samples from gas fields worldwide and analyzing them for helium. More than 14,000 samples have been analyzed. If the analysis shows the gas to be rich in helium, the Bureau makes an engineering study to determine the field's helium reserves, to determine if the field can support a plant.

[44] As a result of the Act, the Bureau now (1976) has about 42 billion cubic feet of helium stored underground for future use, and 12 helium plants have been constructed by private industry. The Bureau stopped buying helium for conservation purposes in 1973 but has entered into long-term contracts with eight private firms to store helium, for a fee, in its underground helium-storage field near Amarillo, Texas. The Bureau also stores helium produced at its plant, in excess of market demand. Extraction of helium from natural gas as it passes through helium plants on its way to fuel markets benefits both the helium producers and the gas companies—the latter, because the helium and some nitrogen, both of which are inert, are extracted in the helium plants and thereby the heating value of the gas is increased.

Demand for helium expanded rapidly in the 1950's, owing to new uses for helium (such as in helium-shielded arc-welding of aluminum and certain other metals, in metallurgical processes, and in the missile and space programs). Helium demand was expected to continue to increase greatly and precipitated the helium-conservation program previously noted.

Because of the vulnerable U.S. *liquid fuels* supply situation in the early 1950's through the Nation's large dependence on imports from the Middle East—which was seen as becoming much more critical in the future because of rapidly increasing demand—the Bureau again turned its attention toward research on the production of liquid fuels from oil shale at the Salt Lake City Experiment Station.

The Bureau had begun such studies in 1916, but suspended them during World War I. In 1919 these investigations were resumed, in cooperation with the State of Colorado, the University of Utah, the Indiana Department of Conservation, and a private group in Salt Lake City. Retorting tests at Boulder, Colo., and refining studies showed that a good grade of motor fuel could be made from shale oil.[45] Research at the Salt Lake City laboratory dealt with the extraction and recovery of nitrogen and sulfur from the shale. Indiana oil-shale deposits were also sampled.

Later an oil-shale pilot plant was operated on Naval Oil Shale Reserve No. 3 near Rulison (Colo.), from May 1926 to June 30, 1927. However, large discoveries of petroleum about that time lessened the interest in oil shale.

The Bureau turned its attention to the synthesizing of alcohols and gasoline from carbon dioxide and hydrogen that were made from coal. This work, performed at Pittsburgh, continued until the drastic budget cuts of the early 1930's.

In 1937 the Bureau began to study the suitability of American coals for liquefaction by hydrogenation; this laboratory program continued until 1944, when the Congress authorized a continuous, long-range research program on the production of motor fuels and other products from coal and oil shale, as substitutes for petroleum.[46]

Meanwhile, the Bureau continued research on oil shale and shale oil in its laboratories at Laramie (Wyo.) and in the experimental mine and pilot plants at Rifle (Colo.). Attention was given to developing methods suitable to mining the shale, cracking and retorting the shale to produce the shale oil, and refining the shale oil to yield an acceptable product. Major problems were technology and economics of mining the huge quantities of shale, and disposal of the waste (spent shale).

At its Bruceton laboratories, the Bureau sought to develop a radically new process for the direct hydrogenation of coal. The Bureau did develop a technically feasible method of gasifying coal at atmospheric pressure, at its Louisiana (Mo.) demonstration plant, but studies showed that costs could be reduced materially by gasifying coal under pressure.

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[45] Shale oil—crude oil obtained from bituminous or oil shale. Oil shale—shale that contains a sufficient amount of oil to permit it to be yielded upon slow distillation.

[46] Public Law 78-290. Since the end of World War II, the Bureau has experimented with the two processes by which the Germans used coal to supply most of the Luftwaffe's aviation gasoline during that War (Bergius-Farben, and Fischer-Tropsch).

Underground coal gasification experiments were begun at Gorgas (Ala.) in 1953, which showed that combustion could be maintained in a coalbed and that low-Btu [47] gas could be recovered. One problem, controlling the quality of the gas produced, was being solved. Another problem, which had severely limited the capacity of the German plants, was the tremendous amount of heat produced in the processes; it was being solved by Bureau personnel in the early 1950's.

One byproduct of the coal-gasification research that was conducted by the Bureau appeared to be the production of nitrogen fertilizer, and this process could be modified to produce synthetic ammonia.

Safety and health

Promoting safety and healthful working conditions in the mines and plants of the mineral industries has been a major activity of the Bureau since its inception in 1910.[48]

In the field of safety the Bureau developed a three-element program: (1) Research and investigations, to determine hazards and to develop effective means of overcoming them; (2) training and related activities, to transfer throughout the mineral industries the knowledge gained; and (3) inspection to determine the specific hazards in individual coal mines, and recommend or require corrective action.

The Bureau's research and investigations on safety and health have covered a wide range of subjects, such as: shock and ignition hazards of mine electrical installations and equipment; control of mine roof and walls,[49] reducing haulage accidents; ventilation problems; control of respirable dust; causes of mine disasters.

Laboratory tests, followed by tests in the mine, provided the basis for the Bureau's permissibility standards (schedules) for coal-mine machinery and electrical equipment. The Federal Coal Mine Safety Act of 1952, and many State laws required the use of permissible machinery and equipment in the early 1950's. In addition, the Bureau required and made tests with permissible flame-safety lamps (in testing for explosive gas and oxygen deficiency) and electric methane [50] detectors (more sensitive than the flame-safety lamp for gas concentrations, but they do not warn of oxygen deficiency).

Beginning in the 1940's the Bureau devoted much attention to the problem of controlling mine roofs. Observing the use of roof-bolting in hard-rock (metal) mines, the Bureau's vigorous promotion of it resulted in its adaptation and use in coal mines.

The Bureau's researches into the causes and prevention of mine disasters (an event that results in 5 or more fatalities) were extended about 1950 into investigations of the isolated accidents that kill only 1–2 people. Although such isolated accidents were receiving little public attention, their impact was great because they were accounting for 93 percent of the deaths each year.

In the field of health research, the Bureau studied fumes and airborne dusts, and their suppression. In addition, it tested respiratory

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[47] Btu—British thermal unit, a measure of heat that is equivalent to the amount required to raise the temperature of one pound of water one degree Fahrenheit (from 63° to 64°F); equals 252 calories.

[48] Research on health and safety continued to occupy the Bureau's attention, although the regulatory and training activities were removed and placed in the newly formed Mine Enforcement and Safety Administration, in 1973.

[49] The principal cause of mine fatalities, throughout the years, has been falling rock, with haulage accidents usually in second place.

[50] A hydrocarbon gas, the chief constituent of natural gas and very combustible; also called "fire damp" by miners.

protective devices, and specified permissible standards. Part of the Bureau's program consisted of analysis of thousands of samples yearly of dusts and air in mines and plants, made for other Government agencies and industry as well as for the Bureau's own inspectors.

Training and demonstration, the Bureau found, not only spread knowledge about safety research and investigations, but made both the trainees and spectators more safety conscious; Bureau followup studies showed that trained mine personnel subsequently exhibited six times the potential to avoid injury.

The Bureau's training in first aid and in mine rescue procedures had resulted by the early 1950's in more than 2 million and 19,000 people, respectively, having completed the courses. Since 1947 accident prevention training has been offered to both coal miners and to supervisory personnel, with 82,000 and 18,000, respectively receiving training.

Dramatic experiences were available to those who were able to participate in the demonstration of violent gas and dust explosions (at the Bureau's experimental coal mine at Bruceton, Pa.), and in the demonstration of the hazards of gasoline vapor, carbon monoxide, and atmospheric contaminants; the latter demonstration (called "The Magic of Fire") was presented to many industrial groups across the Nation, every year. Special training films prepared by the Bureau served as a supplemental training device to the lectures and demonstrations.

From passage of the Coal Mine Inspection Act of 1941 until transfer of this function to the Mining Enforcement and Safety Administration, the inspection of coal mines was a major safety program of the Bureau. This law authorized the Bureau to enter and inspect coal mines, observe hazards, and recommend corrective action. Before 1941, Bureau personnel could enter a mine only with the permission of the operator.

Mere publication of the Bureau inspectors' reports did not result in adequate improvement, so in 1952 the Congress passed the Federal Coal Mine Safety Act,[51] authorizing the Bureau to enforce specific recommendations aimed at preventing disasters. All Federal inspectors were required to be practical mining men, well trained in the principles of coal mine safety; many had been mine superintendents or mine foremen before entering the Bureau via competitive civil service examinations. The Act required the Bureau Director to cooperate with the mine inspection agency of the coal-producing State, and for joint enforcement.

Initial results showed that, in the first year of operation of the Act,

—systematic roof control plans were adopted in more than 2,000 coal mines;

—use of the dangerous black blasting powder was discontinued in more than 1,200 mines;

—main ventilating fans were installed in more than 2,300 mines;

—nearly 1,000 mines began using water to suppress dust where it was being formed;

[51] Public Law 82-552 (to amend Public Law 77-49), July 16, 1952.

—pre-shift examinations for gas were being made in more than 2,300 mines;

—more than 1,500 mines were rock dusted for the first time;

—no-smoking rules were adopted in more than 1,300 mines; and

—use of open-flame lights was stopped in 1,200 mines.

Although the numbers of both fatal and nonfatal coal mine injuries were lower in the period 1942–51 than 1932–41, there was no corresponding decrease in the number of major disasters and their fatalities, as shown in Table 1, below:

TABLE 1.—FATALITIES AND NONFATAL INJURIES IN COAL MINES, 1932–53

	Fatalities	Nonfatal injuries	Disasters	
			Number	Fatalities
1942–51	1,043	52,688	45	896
1932–41	1,233	59,851	46	821

Source: "USBM Manuscript," 1954, pp. 145–147.

However, the frequency rate (per million man-hours) of fatalities and nonfatal injuries did decline, from 1.50 to 1.18 and 72.79 to 59.39, respectively.

River basin activities

The Bureau, in cooperation with the U.S. Geological Survey and other Federal and State agencies, made comprehensive investigations of the mineral resources in river basins of the United States in response to a congressional directive to the Department of the Interior in planning construction of dams for flood control, irrigation works, and the improvement of navigable waterways. These investigations were expected to assure that multiple-purpose dams would be so located as to provide for the orderly and balanced development of those areas, and to contribute to military and economic security.

Foreign mineral activities

The increasing importance of international trade in the U.S. mineral supply situation became evident by the early 1950's when, in comparison with the last half of the 1930's, statistics showed that U.S. imports of copper had increased from 7 percent of total supply to 32 percent, of lead from 7 percent to 43 percent, and of zinc from 5 percent to 27 percent.

Of a group of 30 important industrial minerals, 14 were being imported in quantities that represented 75 percent or more of domestic consumption, and only 10 were imported in quantities of 5 percent or less of domestic needs; the other 6 were imported in amounts that ranged between 25 percent and 75 percent of domestic consumption.

The Bureau's mineral statistics work therefore had acquired a substantial international element, based on foreign information services [52] designed to keep the Nation informed on foreign mineral developments. Annual, and some monthly and quarterly data on foreign production were being gathered along with information on foreign mineral reserves and resources. This information was being published

[52] Public Law 87-826.

in a number of regional and commodity reports, the *Minerals Yearbook*, and other periodicals—and numerous classified reports were prepared exclusively for Federal Government use.

World War I had emphasized the Nation's need for intelligence in the foreign minerals field, as submarine warfare showed the vulnerability of dependence on foreign sources of mineral supply. The same lesson was repeated during World War II, and in the Nation's postwar years.

One of the most important sources of mineral information in foreign countries in the early 1950's was the economic reporting activity of the U.S. Foreign Service of the Department of State. By agreement between the Secretary of State and the Secretary of the Interior, the Bureau of Mines was responsible for technical supervision.[53] In early 1953, five minerals attachés were serving abroad—in southern Africa, Brazil, South America's west coast, and in India and neighboring countries, all of which were important sources of strategic minerals. The minerals attachés provided valuable technical advice to U.S. diplomatic officials and firms who were engaged in maintaining and augmenting Government and industrial supplies of materials during the Korean conflict period.

Since 1940, the Bureau has been sending technical experts to foreign countries to aid in solving problems of production and utilization of mineral raw materials. Originally confined to Latin American nations for the purpose of stimulating production of minerals needed for defense mobilization and war, in the postwar period its emphasis was modified to provide assistance to friendly nations in many parts of the world in order to improve their economic well-being.

During the Korean conflict, mobilization objectives again became uppermost. This work was carried out in cooperation with other Federal agencies such as the State Department's Technical Cooperation Administration, the Foreign Operations Administration, and the General Services Administration.

Immediately after World War II, Bureau technologists were sent into the highly industrialized countries of Western Europe, to assist in the rehabilitation of the mineral industries, which had suffered heavy war damage. This also provided much useful information to the United States on methods and equipment that differed from those being used domestically—as was discussed earlier (footnote 26) in the successful experiments in a West Virginia coal mine with a German coal planer, and in the Bureau's modification of two German methods of producing synthetic liquid fuels from coal by direct hydrogenation and gas synthesis.

An important part of the U.S. technical assistance work abroad was the Bureau's program for training foreign engineers and mineral technologists. In this program, trainees who were carefully selected on the basis of educational qualifications and screened for security clearance before entry into the United States were placed in the appropriate experiment stations of the Bureau, where they studied the kinds of problems they were most likely to encounter in their own country upon their return. Working on nonclassified projects, these men and women trainees remained for 1 year (the younger ones),

[53] Public Law 80-402.

or less (the older ones, who were usually high-ranking staff members of their countries' mining agencies).

Economic and statistical studies

Much of the economic and statistical work of the Bureau of Mines, in the early 1950's as now, was integrated with its various domestic programs and foreign activities. The Bureau conducted special commodity studies, as well as more general economic ones, both to aid in its own work but also to provide information to other Federal agencies and private industry, on which they could base their policies and planning. These results were made available in public documents such as the *Minerals Yearbook*, and in reports to Federal agencies concerned with strategic minerals—such as the Office of Defense Mobilization, the General Services Administration, and the Air Force Department of the early 1950's.

"One of the Bureau's major objectives long has been to minimize overlapping and facilitate integration of (Federal) governmental fact-finding and analysis in the minerals field." [54] In working toward these objectives, the Bureau has cooperated closely with the Bureau of the Budget, the Bureau of the Census, and with other Federal and State governmental agencies.

In 1952, the American Statistical Association made a number of recommendations concerning the Bureau's data-collection and analysis program, in response to a request by Director James Boyd, including the following:

1. Better survey forms should be developed;
2. Professional statisticians should be employed;
3. Better data processing should be designed and implemented; and
4. Consumer surveys should be developed and used.[55]

Basic data gathered by the Bureau on the production, consumption, and stocks of the various mineral commodities provided one of the guides for determining the priorities of Bureau projects dealing with minerals; and they guided Federal officials who were responsible for the Nation's stockpile program. In addition, they helped Federal personnel who dealt with controls on materials, and those responsible for stimulating production of needed commodities.

Similarly, continuation of statistical studies of injuries in the various mineral industries since the 1930's guided the Bureau in the early 1950's in its accident-prevention and safety-training programs.

Taxation and tariff, two fields of Federal policy that deeply affect the mineral industries, were the subject of Bureau studies to obtain a factual and analytical basis for recommendations aimed at assuring the Nation of adequate supplies of strategic and critical minerals and minerals fuels.

Other Federal agencies frequently called on the Bureau of Mines for studies in the minerals field, commonly transferring funds for this purpose. For example, the Bureau performed much of the economic and statistical research on minerals drawn upon by the President's Materials Policy Commission in its report, "Resources for Freedom," in 1952.

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[54] USBM Manuscript Report, 1954, p. 164.

[55] The Bureau has accomplished each of these recommended changes. (Paul Meadows, Bureau of Mines, personal communication, June 23, 1976).

C. REORGANIZATION OF 1974

A number of surveys of Interior bureaus were initiated by the Secretary in June 1953, the report on the Bureau of Mines being the subject of a congressional hearing on August 2, 1954.[56] This report made 39 recommendations that were designed to improve the Bureau's management procedures and practices.

There were four basic recommendations that underlay the 39 specific recommendations of the report on the Bureau, as follows:

a. That the number of administrative regions be reduced from nine to four;

b. That the administration of health, safety, and coal mine inspection activities be separate and apart from scientific and technical research activities;

c. That there be a coordinated strengthening of all statistical and commodity analysis work;

d. That a plan of organization be adopted under which the Washington office retains responsibility for policy and program determination, while conduct and management of research are decentralized.

The Secretary approved all 39 of the recommendations except:

5. That inspectors notify operators and mine safety committees the day before an inspection is started, in order that arrangements can be made to facilitate the inspection.[57]

The Secretary ordered the Director of the Bureau to carry out the remaining recommendations, except for the following, for which the Assistant Secretary for Mineral Resources assumed primary responsibility:

14. That the Bureau should not engage in production activities, and do everything possible to terminate present production activities.

17. That the experimental work done solely by the Bureau on the production of oil shale and oil from shale at Rifle, Colo., should cease, and that no further work be done with the new retort unless there is a substantial contribution by industry under a cooperative agreement.

33. That advisory committees be established and regularly consulted in connection with the functions of the Bureau, particularly in connection with mine health and safety matters and with respect to minerals, solid fuels, and petroleum and natural gas research.

36. That the Assistant Secretary—Mineral Resources—establish a more definite policy governing cooperative, trust, and working funds; and such policy should be implemented by the Bureau through necessary regulations, delegations of authority, and procedures for approval.

The Secretary ordered that the Bureau give attention, first to, the implementation of the following four recommendations, with a deadline of January 1, 1955 (and that a new position of Deputy Director of the Bureau be provided in the organizational scheme):

[56] "Reorganization Plan of the U.S. Bureau of Mines": Hearing before the House Interior and Insular Affairs' Subcommittee on Mines and Mining: U.S. Cong., 83d Cong., 2d sess., Ser. No. 23, Aug. 2, 1954. 65 p.
[57] Ibid, p. 9-10.

1. That the form of organization shown in charts III and IV and Map II, as described in its functional and geographic aspects in part III, be adopted for the Bureau.[58]

19. That there be unified direction of data collection, analysis, and policy appraisal for minerals and fuels; more timely publication of statistical data; and reduction of cost of a minimum for collection and processing of statistics.

20. That the administrative staffs in regional offices should be strengthened by placement, with emphasis upon reassignment, of persons with broad capabilities and qualifications in administrative management.

21. That the Washington staff of the Administrative Division (except the proposed Administrative Branch, Washington) confine its activities to giving advice and guidance to the Director.

The survey, made by a team of five mining experts[59] from outside the Bureau of Mines was very thorough, occupying 72 working days as a group during which they traveled 9,000 miles and talked with 150 Bureau officials and other employees—as well as 80 representatives of mineral and fuel companies, the United Mine Workers, trade associations, universities, State governments, and others.

With regard to recommendation 14, that the Bureau not engage in production activities, this referred to three elements—helium, titanium, and zirconium. Although agreeing that production is certainly not a proper field for the Bureau, whose mission is research and development, the Secretary felt that helium might be considered an exception to this premise, because the Bureau was the sole producer of helium in the United States (and produced more than 97 percent of the World's output), and the Secretary must meet his responsibility to satisfy essential U.S. defense and commercial demands.

Production of the other two elements, titanium and zirconium, was begun at the request of Federal agencies concerned with military security, because of original research done by the Bureau in developing the processes; it had been decided that the Bureau was in the best position to undertake the initial production needed to meet the urgent military needs. The titanium plant at Boulder City, Nev., which by 1954 was producing only 1 percent of the total U.S. capacity, was slated to be phased out in October of that year.

The situation with regard to zirconium, although somewhat like titanium, was several years behind reaching the stage when industry could take over the major share of U.S. production. Accordingly, the Secretary felt that the production of zirconium (and hafnium) at the Bureau's Albany, Oreg., facility should be continued as essential to the national security until industry was willing and able to take over its production.

A recommendation (No. 17) that the Bureau cease its experimental work on production of oil from oil shale at Rifle, Colo., unless a substantial contribution was made by industry under a cooperative agreement, was answered by the fact that the Bureau was at that time discussing such an agreement with several private firms.

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[58] Not included in published hearings; copies supplied by the U.S. Bureau of Mines, November 1975.

[59] Dr. Curtis L. Wilson, Dean of the Missouri School of Mines; John C. Kinnear, Sr., former vice president of Kennecott Copper Corp.; Dennis L. McElroy, vice president of Pittsburgh Consolidation Coal Co.; J. R. Butler, vice president of the Independent Petroleum Association of America; and Spencer S. Shannon, former Director of the former National Security Resources Board's Materials Office. Staff assistants were Henry P. Caulfield of the Department's technical review staff, and George E. Robinson of Interior's Office of Administrative Secretary.

D. THE LAST TWO DECADES

Annual reports

The Director of the Bureau of Mines has prepared an annual report, beginning with its first fiscal year, 1911. In 1925 the Bureau was transferred from the Department of the Interior to the Department of Commerce, and in 1933 the Director's annual report was no longer issued separately but as part of the annual report of the Secretary of Commerce. When the Bureau was returned to the Interior Department in 1934, the practice was continued of having the Director's report constitute part of the Interior Secretary's annual report.

In 1964 the Secretary's annual report was changed in format to an oversize quarto attractive and colorful "Conservation Yearbook." Although the Bureau's accomplishments are presented therein, because of the thematic nature of this new yearbook a complete chronicle of the agency's significant activities is not presented. A more complete record is found in the *Annual Report of Progress* of the Bureau of Mines, an internal document that consists of little more than brief listings of activities during the fiscal year; the Bureau's archives of annual reports of progress go back to 1954, with 1973 being the last.

Beginning with the year 1971 the Bureau began to publish *Bureau of Mines Research*, an annual report that highlights significant research projects and mineral-intelligence studies. In 1974 these highlights were classified under five general categories: (1) energy, (2) metallurgy, (3) mining, (4) mineral supply, and (5) mineral-position analysis. A very useful bibliography of publications by Bureau personnel, arranged according to the first four of the five subheadings noted in the preceding sentence, is presented therein, alphabetically by author.

In addition, comprehensive annual reports are prepared for: (1) Coal Mine Health and Safety Research; and (2) Metal and Nonmetal Mine Health and Safety Research. These two series of reports, entitled "Annual Report of the Secretary of the Interior under the Federal Coal Mine Health and Safety Act," and "Report of the Secretary of the Interior on Administration of Public Law 89–577;" are calendar year documents that began in 1970. They report on all health and safety activities, including both research by the Bureau of Mines and since 1973, MESA's enforcement and education/training activities. Highlights of Bureau activities during the past 20 years are presented in the following paragraphs.

Administration

In fiscal year 1962, the Bureau had more than 200 cooperative agreements in effect, more than half of them with non-Federal agencies. Bureau scientists and engineers in that year reported 12 new inventions, filed 14 patent applications, and were granted 16 patents.[60]

Experiment stations

In fiscal year 1955, the Reno, Nev., Rare and Precious Metals Experiment Station was dedicated, on September 25, 1954, and stations at Raleigh N.C., and Mount Weather, Va., were closed. The Morgantown W. Va., petroleum and natural gas experiment station was dedicated on May 14, 1955. In fiscal year 1956 the Bureau

[60] Patents awarded to Bureau scientists and engineers result in no income either to the patentee or the Bureau; rather, the patented process or equipment is made available without charge to the public.

leased to industry its Northwest Electrodevelopment Laboratory, in Albany, Oreg., which was later returned to the Bureau.

In fiscal year 1960 the Bureau's Metallurgy Research Center at Twin Cities, Minn., was occupied by Bureau personnel transferred from other locations; it was dedicated on June 10, 1961.

Foreign activities

In fiscal year 1963, a National Academy of Sciences' study for the President, entitled "Research Needs in the Natural Resources Field," resulted in the expansion of the Bureau's reporting on international mineral developments.

Also in that year, with U.S. Agency for International Development sponsorship, 17 Bureau technologists provided minerals assistance to eight countries (Afghanistan, Bolivia, Indonesia, South Korea, Mexico, Nepal, Pakistan, and Taiwan). The Bureau also helped train 78 foreign mineral technicians, from 19 countries.

Reorganization of the Bureau

As recommended by the Interior Secretary's survey team, the Bureau's 1954 reorganization was completed by January 1955—permitting the helium program and the health and safety units to function as separate units. The Bureau's regions were reduced from nine to five; a program staff was created; a Division of Foreign Activities was set up; and the Bureau's anthracite program was assigned to the Division of Solid Fuels.

Titanium and zirconium plants

In fiscal year 1955 the Government plants that had been producing titanium and zirconium were leased by industry, and were later returned to the Bureau.

University fellowships

In fiscal year 1966 the Bureau began to expand its research fellowship program, which provided opportunities for undergraduate and graduate students to work part-time in Bureau laboratories and research centers. Cooperative agreements for such fellowships were in effect at more than 20 educational institutions throughout the United States.

Energy

Anthracite

In late 1955 the Bureau's Anthracite Experiment Station at Schuylkill Haven, Pa. had been established, to review and evaluate mine-drainage projects proposed by the Commonwealth of Pennsylvania under Public Law 84–162 (69 Stat. L. 352), with $8.5 million State funds and an equivalent amount of Bureau of Mines funds. In fiscal year 1957, 13 projects were reviewed and approved, totaling $5.5 million. In fiscal year 1958, four new mine-flood abatement projects, costing $0.7 million Federal funds, were approved; in addition, 12 projects that were to cost $6 million were being prepared by the Commonwealth of Pennsylvania for submittal.

In fiscal year 1957 the hydraulic mining project had gotten underway, using a nozzle for jetting the mine face to break out the coal.

Preliminary research on hydraulic transportation of anthracite was begun in fiscal year 1960.

In October 1962, the Congress broadened the scope of the Federal-State mine-water control program, and authorized the filling of abandoned mines in the interest of public health and safety.

The Bureau has cooperated with the Commonwealth of Pennsylvania on strip-mine rehabilitation on State-owned lands, which also provided badly needed jobs in the depressed Appalachian Highlands.

Bituminous coal

In fiscal year 1956 the Bureau contracted out a survey of coal-research possibilities, to Bituminous Coal Research, Inc. The Bureau's second experimental coal mine at Bruceton, Pa., was completed.

In fiscal year 1959 the Bureau began new studies (1) on the application of hydraulic mining methods to bituminous coal, and (2) for removing methane gas from coal beds in advance of mining.

In fiscal year 1961 the Bureau discovered that bacteria could be used for extracting sulfur from coal, based on the principle that certain bacteria accelerate the oxidation of iron in pyrite. The next year the Bureau was able to achieve 80 percent removal of the pyritic sulfur from some low-rank coals, by bacterial action.

In fiscal year 1962, the Bureau investigations in the Beluga coal field (Alaska) were completed, with core drilling showing subbituminous coal reserves of more than 20 million tons in seams thicker than 50 feet—apparently suitable for opencut mining.

The Bureau discovered in fiscal year 1962 that virtually unused low-grade coal in southern Utah could be upgraded for use in cement manufacturing in California.

Coal research

Also in the 1960's the Bureau developed the Synthoil process for the purpose of converting coal to liquid hydrocarbons as a hedge against the decreasing U.S. petroleum reserves. In 1970 the Bureau developed a method of converting organic wastes such as garbage, sawdust, and old tires to synthetic oil.

During this same period the Bureau intensified its efforts to determine the "washability" of coal from principal seams throughout the country. A total of 455 samples were tested to determine the sulfur and ash-release potential of coal when treated in conventional flowsheets. Technological advancements were achieved in separating fine coal by flotation, clarifying and reusing plant-processing water, and removing excess water from fine coal.

Several reports were issued during the decade on the physical and chemical properties of coal. Such data are extremely important in planning experiments to remove organically combined sulfur from coal and to improve the coking characteristics of more coals.

In 1972 the Bureau initiated underground coal-gasification experiments in a thick seam near Hanna, Wyo. A gas containing about 125 Btu's per cubic foot was obtained on a steady-state basis.[61]

Coal gasification

In fiscal year 1954, Bureau methods for gasifying coal at atmospheric pressure were adopted by industry and applied commercially.

[61] Schrider, Leo A., and James W. Jennings, "An Underground Coal Gasification Experiment, Hanna, Wyo.": Society of Petroleum Engineers Preprint SPE 4993, 49th Annual Fall Meeting, Houston, Tex., Oct. 6–9, 1974, table 2.

The Gorgas, Ala., underground gasification project for unmined coal was reactivated, with hydrofracturing by a mixture of oil and sand. The permeability [62] was increased by 85 times, and fracture openings were induced that extended as much as 600 feet from the injection point. By fiscal year 1958 these studies had shown that such gasification was currently uneconomic, however.

In fiscal year 1962 the Bureau discovered that catalytic hydrogenation of coal could successfully yield large quantities of hydrogen.

The Bureau had been working since the early 1960's to develop its Synthane process [63] for making synthetic methane and to prove its commercial feasibility. In June 1970, the Bureau awarded a contract for the design of a prototype plant capable of producing 1 million cubic feet per day of pipeline gas. However, because pilot plant studies were still needed, to demonstrate the operation of the process on a larger-than-bench scale and to permit further refinements so as to encourage industry to build the full-scale plants, an increase of $4.5 million in the Bureau's fiscal year 1973 budget was requested. The Bureau estimated that its primary involvement would end after the pilot-plant stage, when industry was expected to take over.

Lignite

In fiscal year 1954, six commercial dryers went into operation, using a Bureau-developed process to supply dried lignite for electric-energy boilers using pulverized coal.

In fiscal year 1955 a comprehensive report on lignite technology was published, and in fiscal year 1956 the safe storage of lignite mined from the Garrison Dam Site (North Dakota) was being investigated.

The Bureau sponsored and held a total of nine Lignite Advisory Committee symposia for the purpose of bringing industry representatives, university personnel and Federal agency experts together to discuss problems associated with lignite, and to plan programs for increasing the utilization of lignite.

The Bureau demonstrated that slag buildup on fire tubes and other heat-transfer surfaces in lignite-fired boilers was caused by low-melting sodium compounds in the coal. Several processes for reducing the sodium content were tried with modest success. More effort is planned, using ion-exchange technique because it shows the most promise.

Oil shale

At Rifle, Colo., in fiscal year 1954, gas-combustion retorting tests produced more than 1,000 barrels of oil from 2,240 tons of raw oil shale, following which all operations of the chemical and refining units were suspended.

On February 28, 1955, a serious roof fall damaged some mining equipment; the mine remained shut down at the end of the year. In June 1956, all development work by the Bureau on the Naval Oil Shale Reserves at Rifle (Colorado) was shut down.

In fiscal year 1965 the combined hydrofrac-explosive technique, being tested to recover oil and gas from tight formations, was studied by the Bureau as a possible key to unlock the oil from the huge oil-shale reserves.

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[62] Permeability—ability of a material to permit fluids to flow through it.

[63] The Synthane process, which produces a sulfur-free methane gas that compares with natural gas in Btu content, is relatively simple and cheap, because it employs fewer steps and less equipment.

In fiscal year 1966 the first stage of a multimillion dollar program by industry of experimentation was carried out, with financial backing ($1.5 million) from six major oil companies, at the Anvil Points (Colorado) installation formerly operated by the Bureau of Mines. These initial experiments, made possible under a leasing agreement with the Interior Department, included successful trials with two small, Bureau-designed oil-shale retorts and also a limited amount of research on the mining and crushing of the shale.

Meanwhile, the Bureau continued its own research on the fracturing and retorting of oil shale underground—which would avoid mining costs and the cost of disposal of the spent shale after retorting. One promising approach was the use of high-voltage electricity to burn pathways through the oil-shale deposit.

The Bureau was also considering in fiscal year 1966, in cooperation with the Atomic Energy Commission, the possibility of an underground nuclear explosion to create a large chimney of crushed shale, which could then be retorted underground.

Petroleum and natural gas

The Bureau completed part of a long-range Interior Department study in fiscal year 1959 to estimate future U.S. petroleum and natural gas requirements.

In fiscal year 1960 the Bureau achieved enhanced efficiency in petroleum waterflood projects for the secondary recovery of oil in California and Montana.

The Bureau's experimental fireflood near Reno (Pennsylvania) was well underway in fiscal year 1963—a second field test of thermal recovery, in cooperation with an oil-refinery company.

In fiscal year 1965 the Bureau was cooperating with the Atomic Energy Commission in studying the possibilities of using nuclear explosives to fracture and loosen up the oil and gas reservoir rock. This research supplemented other investigations by the Bureau on a technique known as hydraulic fracturing—the fracturing of reservoir rock by pumping a slurry of sand and liquid down boreholes under high pressure, followed by chemical explosives injected into the cracked rock which extended the original fractures caused by the slurry. These efforts were attacking the significant dual problems of the 50 percent of the oil and gas reserves that is left in the rock when producing wells are pumped, as well as the tight formations that do not yield such fluids readily.

In fiscal year 1967 the Bureau joined the AEC and the El Paso Natural Gas Co. in *Project Gasbuggy*. Agreement to proceed with the experiment, in which a nuclear explosive would be detonated deep underground in a tight natural gas formation (Pictured Cliffs Formation in New Mexico), was reached in early 1967, with the detonation scheduled for the Fall of 1967. The volume of gas that could be recovered economically from that low-permeable formation was expected to be increased by seven times. However, Projects *Rio Blanco* and *Rulison*,[64] as well as Gasbuggy, have failed to meet the early expectations both as to economics and environmental and safety considerations.

[64] Nuclear tests conducted in Colorado in 1973 and 1969, respectively, in which the AEC and the Bureau (with industry participation in Rulison) attempted to recover natural gas from tight formations.

The Bureau assembled a pollution-free automobile in 1967 to show practical measures for eliminating or reducing the emission of burned and unburned hydrocarbons as exhaust fumes, of crankcase fumes, and of fumes from gas tanks and carburetors. This car served as a model which automobile manufacturers used in designing pollution controls for production models.

In 1972 the Bureau developed a method for identifying crude oil by its characteristic hydrocarbon linkages. In 1975 the Coast Guard used the "fingerprints" of oil to identify the ship that spilled the oil in an unreported spill near the Florida coast line. The shipowners were fined for polluting the sea and shoreline.

The Bureau has engaged in cooperative research to recover and recycle water pumped from oil wells at Long Beach, Calif. The water is pumped back underground to prevent subsidence and encroachment of salt water into fresh water aquifers. About mid-1960 the Bureau developed a mathematical model for the proper oil-well configuration to insure optimum output from a reservoir with maximum recovery.

Helium

Management of the helium program of the Bureau was reorganized in fiscal year 1955, with headquarters established at Amarillo (Tex.). The four helium plants (Exell, Tex.; Shiprock, N. Mex.; Amarillo, Tex.; and Otis, Kans.) produced record amounts, but still below the demand.

In fiscal year 1958 the Department of the Interior announced a program to conserve the helium that was being wasted into the atmosphere when helium-bearing natural gas was burned; it projected the construction of 12 new helium plants, costing $224 million, to meet anticipated U.S. helium needs until 1985 through the recovery of 32 billion cubic feet of helium.

A fifth Bureau helium plant was under construction in fiscal year 1959, at Keyes (Oklahoma), adding 290 million cubic feet per year production capacity.

In 1961 the Helium Research Center was established in Amarillo (Tex.).

Under the Helium Act Amendments of 1960, the Bureau began negotiating with industry to construct plants for producing helium for sale to the Federal Government. In fiscal year 1962 the Bureau awarded long-term helium-purchase contracts to industry (22-year purchase agreements), whereby four companies would build and operate five helium plants to recover helium from natural gas going to fuel markets; this consumed all of the $47.5 million per year of contracting authority that had been granted to the Bureau by the Congress. In fiscal year 1963, three private companies extracted nearly 320 million cubic feet of crude helium [65] from their natural gas, and sold it to the Bureau.

The construction of a 427-mile pipeline system to transport crude helium from industry's plants to the Bureau's Cliffside Field near Amarillo, Tex., was completed in fiscal year 1963, at a cost of about $8.5 million.

In fiscal year 1964 the Interior Secretary could report [66] that:

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[65] The companies extracted "crude" helium, which contained about 30 percent nitrogen and other gases. The Government paid only for the helium, although the total "crude" helium mixture was delivered to the pipeline and stored underground.

[66] "Quest for Quality," U.S. Department of Interior Conservation Yearbook (1964), 1965, pp. 42–43.

In Congress it has been called an ideal conservation program, effectively combining efforts of government and industry in a vital investment for the future. Today, this program is saving helium at the rate of 275 million cubic feet each month. The program now underway promises to conserve enough of this versatile element to meet foreseeable needs well beyond the year 2000. Without the effort, adequate supplies might not have lasted past 1985.

The demand for helium, which by 1964 had increased to 11 times the 1950 demand, was due to a host of new uses: (1) shielding of easily contaminated metals during arc welding, (2) leak-testing of vital parts of missiles, rockets, and components of air conditioners and refrigerators, (3) laboratory tests for quality control in hundreds of commercial items ranging from wines to wonder drugs, (4) in cryogenics,[67] (5) as a medium for conducting heat from nuclear furnaces, and (6) as the mechanism for injecting liquid fuels into rocket engines.

In fiscal year 1966 the Bureau's helium-conservation program took a new direction, with the signing of a contract under which the Bureau would store (and receive $30,000 in payment the first year) over the next 5 years as much as 300 million cubic feet of helium owned by a private company—one of the several companies from which the Bureau was buying helium for conservation under long-term agreements.

The year-long Helium Centennial, inaugurated by Vice President Hubert Humphrey late in calendar year 1967, was launched by the Bureau as a conservation-consciousness program, to celebrate the discovery of helium 100 years ago. Helium's beneficial use potential had gone unrealized for many decades after its discovery, and "our limited reserves were needlessly wasted for many years until the Congress, impressed with the need for assuring future supplies, enacted legislation permitting helium's large-scale conservation." [68] Special events at major scientific meetings, together with the construction and dedication of a special monument at Amarillo, Tex., marked the centennial.

Mining health and safety

In fiscal year 1957 a committee to advise the Bureau on respiratory protection against radioactive materials was formed, to include representatives of the Atomic Energy Commission, the AEC contractors, the Industrial Safety Equipment Association, and the U.S. Public Health Service.

Commercial development was underway in fiscal year 1959, for two Bureau pieces of equipment that would save lives and avoid injuries: (1) a portable mine-facing shield, and (2) a pocket-size methane-detector that uses only one standard flashlight cell.

In fiscal year 1961, renewed emphasis was being given to silicosis in metal mines, a subject that had been under study since 1958, and it was completed in fiscal year 1962. In addition, alpha-emitting decay products of radon were being studied in uranium mines in fiscal year 1961.

Early in 1962 the Bureau was designated by the Secretary to conduct field investigations on Public Law 87–300—health and safety in metal and nonmetal mines.

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[67] Cryogenics—the field of low-temperature research.
[68] "It's Your World," U.S. Department of Interior Conservation Yearbook No. 5 (1968), 1969, p. 71

The Bureau was studying ways to develop safe and efficient air-conditioning systems for deep, hot mines in fiscal year 1965, because the quest for minerals was being pushed to greater and greater depths with increasingly high temperatures and humidities.

President Johnson signed the "Small Mines Act" in fiscal year 1966, extending to some 50,000 of the Nation's coal miners the same protection against disasters as was provided by Federal inspection of large [69] coal mines.

The Bureau announced the successful development of the world's first machine-mounted methane monitor in fiscal year 1966, to guard against the deadly menace of gas explosions in underground coal mines.

Early in fiscal year 1969 the Bureau had made 18 major recommendations to the Congress for strengthening the safety provisions of the Federal Coal Mine Safety Act of 1941, which had been amended in 1952 and 1966. In November 1968, a series of explosions claimed the lives of 78 underground coal miners in a large West Virginia mine. Like other disasters in the past, this one touched off new public demands for measures to improve conditions that have made coal mining the most hazardous major U.S. occupation.

One of President Nixon's first major legislative proposals to the Congress in 1969 dealt with coal mine health and safety. By December of 1969 the Congress had sent to the President a set of strong coal mine health and safety measures, which he immediately signed into law.

In fiscal year 1970 the Bureau achieved some success in its attack on the primary killer in underground mines, falling roof rock, when it developed a technique to give advance warning by sensing the rock's temperature from a safe distance. An infrared (heat) device scans the roof and walls; the loose rock shows up as cooler because the ventilating air has more access to it through pores and fractures. Special infrared thermometers were being designed at year's end.

In a related development, the Bureau found that special, high-strength plastics can heal fractured rock in a mine wall or roof. The plastic is injected as a liquid, then treated with heat and catalysts to solidify it—a process known as polymerization. Some rock thus bonded with polymer is stronger than before it was fractured, and in addition it possesses a plastic coating that resists the deteriorating effects of mine water and heat. The Bureau's aim was to devise a method that would make the walls and roofs of mine passageways completely self-supporting.

Late in 1969, when it became apparent that the new Federal Coal Mine Health and Safety Act of 1969 would be passed, the Bureau began hiring and training the new coal mine inspectors who would be needed for enforcement of the Act. The staff of 250 was enlarged to 1,000, by the middle of 1971. A National Mine Safety Academy was established at Beckley, W. Va., to train new mine inspectors, with university-level courses, to be ready by the spring of 1974.

The Bureau expected to be able to make 30,000 mine inspections by mid-1971—or roughly 85 percent of the number required by the Act.

A similar inspection effort was underway by the Bureau under the Federal Metal and Nonmetal Mine Safety Act of 1966, which gave pro-

[69] Those that employ more than 14 people underground.

tection to miners in the Nation's 18,000 noncoal mines. Health and safety regulations, recommended to the Interior Secretary by special advisory panels, took effect on July 31, 1970.

Since 1971, the first full year of operation, the statistics of coal mine inspections have increased markedly, as shown in the table below.

	1970	1971	1972 [1]	1973 [1]
Inspectors	564	1,055	1,521	1,528
Inspections	[2] 9,000	26,000	68,000	90,000
Full inspections	[2] 1,600	4,000	12,336	15,150
Notices of violations of standards	38,000	60,000	76,000	71,155
Orders to withdraw miners from mines	1,500	4,000	2,800	3,200

[1] "Annual Report of Secretary of the Interior, Administration of the Coal Mine Health and Safety Act, 1973," p. 3-6.
[2] 9 months.

The Bureau designed a prototype, experimental mine-air surveillance system to monitor several atmospheric conditions that contribute to hazards underground: methane, hydrogen, carbon monoxide, temperature, rate of temperature change, velocity of ventilating air, and noise. A contractor designed, assembled, and installed the experimental system, using only manufactured sensors, gages, and instruments whose utility was already established at the Bureau's Bruceton, Pa., experimental mine, and it was being tested in 1973.

In mid-1973, Interior Secretary Morton established the Mining Enforcement and Safety Administration (MESA) as a separate organization to carry out the health and safety enforcement activities formerly assigned to the Bureau of Mines. The Bureau was to continue the health and safety technology research and development, and would work with MESA on the transfer of this technology to the operating mines. About 3,000 people were transferred to MESA from the Bureau, plus facilities; the Bureau continued to provide administrative support.

Coal dust

The biggest environmental threat to the health of coal miners is coal dust—generated in the cutting and moving of coal—which finds its way into the smallest terminal passages of the miners' lungs. Black lung (pneumoconiosis), which can result from years of exposure to this kind of dust, can cause death. A significant advance in coal-dust reduction was achieved during 1970 by the Bureau, which found that the exposure of miners to dust generated by continuous-mining machines could be greatly reduced by high-pressure auxiliary fans. Since most coal mines were already equipped with special ventilating systems, the cost of installing the auxiliary fan systems would be moderate. This important discovery made it possible for mine operators to comply with the first Federal dust standard, set by Congress in 1969, by using conventional and readily available equipment.

In the next few years, Bureau-contracted research was to explore ways to redesign the cutting heads of continuous-mining machines so as to produce lesser amounts of respirable dust and larger pieces of coal, and to test water sprays, water injection, and chemical foam as a dust suppressant.

The Bureau has also shown that, in some kinds of mining where explosives are used to break the coal, dust production can be reduced by stemming [70] the explosive charge with water-filled bags.

Degasification

When methane gas is released during coal mining, it is a potential explosion hazard in underground mines. The former practice to control the release of methane had been solely to move it away from the coal face by fresh air pulled through the mine by massive ventilating fans; in addition to being costly, this procedure did not completely eliminate explosions. The Bureau designed a method for draining most of the gas before mining began. With funds provided under the Coal Mine Health and Safety Act of 1969, the Bureau arranged for a degasification demonstration at the Federal No. 2 mine of Eastern Associated Coal Corp., in Monongalia County, W. Va. A large-diameter, 839-foot hole was drilled from the surface into an unmined section of the Pittsburgh coal seam where it was 8 feet thick. The hole was enlarged to 14 feet in diameter at the bottom, and seven long, horizontal holes were drilled out into the coalbed, like spokes from a wheel hub. The bottom of the large hole was fitted with piping, valves, and gages, to measure gas pressure, flow rate, and gas quality—as well as to carry the gas to the surface for venting.

After several months of legal negotiations, a hookup was arranged for with a commercial natural gas pipeline, only 400 feet away, and on January 28, 1974 this innovative technology was put to the test. This single, experimental borehole in 1974 was adding 750,000 cubic feet of gas per day to the fuel-short Northeastern States—enough to meet the daily cooking needs of 18,000 households. The Bureau estimated that the Nation's natural gas reserves would be doubled, if all the methane that is locked up in coal beds could be extracted economically.[71]

Mining research

Marine mining

The Bureau began research into marine mining technology in fiscal year 1963, in anticipation of the need when the United States would begin to seek the vast mineral deposits on the deep sea bed. The Bureau's entry into marine minerals research began with a ton of manganese nodules that were dredged from the ocean floor near Baja California.

The new Bureau-industry program of marine-mining technology became operational in fiscal year 1965, with the launching of the Federal Government's first marine-mining research vessel (a 65-foot former Army cargo carrier). A second, larger vessel for deep-water operations was made available in fiscal year 1966, and a third was being refitted. The Bureau was joined by the State of California, the Atomic Energy Commission, the Department of Defense, and three industrial partners in this effort.

In fiscal year 1967 the Bureau's newest and largest ocean-mining research vessel, the *Virginia City*, began sampling bottom sediments on the Continental Shelf off Alaska, Oregon, and California—looking

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[70] Stemming: the act of pushing and tamping the material in a shothole.

[71] "The Choices Ahead," U.S. Department of the Interior Conservation Yearbook Series No. 10, 1974 p. 19.

especially for the heavy metals such as gold, silver, mercury, and tin, all of which were in short supply domestically.[72]

Underground construction and mining

At the request of the Army Corps of Engineers, the Bureau began work on "Design of Underground Installations in Rock," based on the Bureau's fundamental research on the physical properties of rocks.

The Bureau's research on the use of precast concrete to solve ground-support problems was producing favorable results in fiscal year 1960 at an Idaho metal mine.

In February 1961, the Bureau sponsored the International Symposium on Mining Research at the Missouri School of Mines, in Rolla, Mo.

The Bureau developed an explosive rockbolt for mining in soft rock in fiscal year 1963, traditionally a difficult and hazardous enterprise.

For several years before fiscal year 1967 the Bureau had been attempting to initiate a program to develop a revolutionary technology of rapid excavation: tunneling through the Earth's great variety of rock strata with safety, speed, and efficiency far beyond current practice. New techniques for breaking rock, for hauling materials, for supporting tunnel roofs and walls, and for controlling the total underground environment must be integrated into a single, continuous, flexible, and economical excavation system. Such technology would benefit far more than mining; for example, uses of underground space such as for transit facilities, for storage areas, and for tunnels for transporting water, transmitting power, and disposing of wastes. A Federal contract was awarded to the National Research Council, to identify areas where rapid-excavation research should be concentrated, and the Bureau was named prime contractor by the eight other Federal agencies supporting the NRC study. However, the research and development program recommended as a result of this study was not funded.

The Bureau's mining/research capabilities were recognized again in June 1970, through its major role in the International Advisory Conference on Tunneling, held in Washington, D.C. Under the auspices of the Organization for Economic Cooperation and Development, 20 nations sent delegations to the U.S. conference, to identify inadequacies in underground excavation technology and to suggest corrective action. The Bureau coordinated the activities of nearly a dozen U.S. agencies in the conference, and contributed significantly to the drafting of the final report.

Metallurgy

In fiscal year 1960 the Bureau devised new applications of solvent extraction, and electrolytic processes were successfully developed in the experimental production of metals such as nickel, cobalt, vanadium tungsten, molybdenum, columbium, tantalum, and chromium; in fiscal year 1963 vanadium, beryllium, cadmium, and the rare earths were added.

[72] The Bureau's marine mineral mining research program was transferred to the National Oceanic and Atmospheric Administration in fiscal year 1971. (President's Reorganization Plan No. 4 of 1970, dated July 9, 1970.)

Bureau metallurgists developed new techniques for making special shapes of high-purity tungsten (the most promising missile metal), and they were likewise successful in using uranium to impart new strength to steel.

A corrosion-warning system, developed by the Bureau, enable savings of $5 million per year from corrosion at Federal facilities.

In fiscal year 1963 the kyanite industry adopted a Bureau-developed process for separating kyanite from its enclosing rock.

Air pollution

The Bureau began a study of the role of the internal combustion engines' exhaust gases in air pollution in fiscal year 1956, following the authorization by the 84th Congress of investigations into air pollution and stream pollution. By fiscal year 1967 these researches were being directed to conserve the 10 percent of the gasoline consumed by autos that was thus wasted, and to develop a potential antismoke automobile. The Bureau also began research on diesel-exhaust pollutants in fiscal year 1966. This work was carried out at the Bureau's Bartlesville Petroleum Research Center.

In fiscal year 1962 the Bureau developed a process to produce hydrofluoric acid from waste fluosilicic acid, thus recovering a useful product from noxious gases.

In fiscal year 1965, Bureau scientists were pursuing the development of methods for reducing the discharge of sulfur dioxide into the atmosphere not only from the burning of coal and fuel oil but also from stack gases being discharged by many ore smelters. The Bureau's just-developed alkalized-alumina process was one of three that in 1965 held promise for reducing this type of air pollution, and in fiscal year 1966 this work was continued. It was performed largely at the Bureau's energy research facilities.

In fiscal year 1967 the Bureau's pilot-scale testing of its process to remove sulfur from combustion gases before they reach the atmosphere, by using pellets of alkalized alumina to absorb the sulfur, had revealed no technical barriers insurmountable to commercial-scale application.

"Fly ash," the gray powdery residue of unburned minerals generated by industrial furnaces, had been collected by precipitators installed in stacks of fuel-burning industries many years ago, to remove this troublesome waste material from their stack gases. However, disposal of the mountainous quantities (some 20 million tons each year) was a staggering physical and economic task—costing industry $0.50–2.00 per ton. Bureau research by fiscal year 1967 had shown that fly ash is a potentially valuable material—to strengthen cement and concrete block and brick, to stabilize soils, and as a filler in asphalt paving. In addition, fly ash contains potentially recoverable amounts of such rare and high-priced metals as beryllium and germanium.

In 1968 a team of Bureau metallurgists was assigned the job of developing a more effective, up-to-date method of removing sulfur dioxide from smelters, at its Salt Lake City Metallurgy Research Center. First they searched the patent and technical literature and discovered a number of liquid organic compounds that would absorb sulfur dioxide from gas mixtures passed through them; solid sulfur

could then be formed from the sulfur dioxide, by bubbling hydrogen-sulfide gas through the absorber liquid. The Bureau determined that a solution of citric acid and sodium citrate in water was one of the best for absorbing sulfur dioxide from simulated mixed gas. Industry, however, was reluctant to invest in unproven technology, until a copper producer tested the citrate process in a small pilot plant at its Arizona smelter, in the fall of 1970. In late 1972 a chemical producer, an engineering firm, and a pollution-control manufacturer joined in a venture to build a pilot plant to test the Bureau's process on stack gas from a powerplant in Indiana.

The pilot plant testing was concluded successfully. The Bureau also has operated a pilot plant at a lead smelter in Idaho, and is presently negotiating for the construction and operation of a commercial-scale demonstration unit at an electric-power generating station.

Low-grade aluminum ore

The anorthosite plant at Laramie, Wyo., was shut down in March 1954, having produced 800 tons of alumina. In fiscal year 1957, a commercial plant using a Bureau-developed process to upgrade domestic bauxite to produce aluminum, was being constructed.

Columbium and tantalum

In fiscal year 1957 a commercial plant was being constructed in Muskogee, Okla., to separate columbium from tantalum.

Iron and steel

A new blast furnace feed, prepared with Bureau specifications and techniques at its Twin Cities Research Center (Minnesota), and averaging 80-percent iron, was tested in fiscal year 1962 at the Bureau's experimental blast furnace at Bruceton, Pa. Prereduced with North Dakota lignite and made from Lake Superior taconite [73] ore, this pelletized feed made possible the highest steel productivity and lowest fuel-consumption rates ever recorded in the experimental furnace. This process showed promise for the economic processing of the huge U.S. reserves of nonmagnetic taconite.

The operation of the Bureau's experimental pilot plant at Kings Mountain, N.C., was terminated in fiscal year 1962, after it had proved the practicality of the Bureau flotation method of concentrating beryl [74] from spodumene [75] mill tailings.

A 2-year research program to increase blast-furnace efficiency and improve pig-iron quality was begun in fiscal year 1963, with $2 million from Blast Furnace Research, Inc. (22 major iron and steel producers), using the Bureau's experimental blast furnace at Bruceton, Pa.

Nonmagnetic iron deposits at Ishpeming, Mich., containing 36 percent iron, became commercially producible when Bureau metallurgists used a specialized adaptation of standard mineral technology to upgrade them to a valuable concentrate. Bureau work on this prob-

[73] Taconite—low-grade iron formation, a complex iron-silicate rock from which it is exceedingly difficult to separate the iron.
[74] Beryl—a beryllium-aluminum silicate mineral containing some sodium, lithium, cesium, and water.
[75] Spodumene—a lithium-aluminum silicate mineral.

lem had begun in the late 1950's, with the use of froth flotation.[76] The Bureau worked painstakingly to find the proper combination of chemicals and conditions, but the major problem was that, when the ore was ground finely enough to liberate most of the iron, too much iron was rejected into the waste. Finally, after 12 years of work, a commercially usable process was developed by the Bureau, and the Interior Department obtained a patent in behalf of the public.

The technology developed by the Bureau has been adopted for use in a large-scale commercial venture at Tilden, Mich. This plant, representing an investment of nearly $200 million, opened in mid-1974 and produces 5 percent of the Nation's supply of high-grade iron-oxide pellets from nonmagnetic taconite.

Mica

An Alabama plant, which was producing scrap mica for use in grinding applications, had doubled its output in fiscal year 1964 by adopting a Bureau method to recover mica that was formerly lost in processing.

Solid waste

The Solid-Waste Disposal Act of 1965 gave to the Bureau its first authority to award grants as well as contracts for research and development. By the end of fiscal year 1966, the Bureau, after having reviewed and evaluated the first group of responses, awarded the first contract and the first grant for research on solid-waste disposal.

Auto graveyards

Metallurgical research by the Bureau was developing by fiscal year 1965 a process to help convert part of the auto graveyards (resulting from the 5 million autos discarded each year) from a national eyesore into a national asset. Finely-shredded ferrous metal scrap, recovered from auto carcasses, would be used in magnetizing the abundant domestic low-grade iron ore into an iron concentrate, which would help revive the economy of several iron-mining areas of the northern part of the Great Lakes region. In fiscal year 1966 the Bureau awarded a contract for engineering-design studies preceding construction of a plant on Minnesota's iron range, to demonstrate the process on a commercial scale.

Also in fiscal year 1966 a pilot plant was being constructed by the Bureau in Albany, Oreg., to test a Bureau method for making auto hulls more readily usable in iron blast-furnaces, by selectively melting out the copper, aluminum, zinc, and other nonferrous metals. (Figs. 11–12).

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[76] Finely ground iron ore is mixed with water and special chemicals that foam when agitated; air is introduced into the swirling mixture, and a light, foamy layer forms on the surface. The valuable minerals attach themselves to the air bubble sthat collect at the top of the unit, where they are captured by skimming off continuously. Wastes are collected at the bottom of the unit.

FIGURE 11.—Plant for smokeless combustion of automobile carcasses, adjacent to open-burning disposal.

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FIGURE 12.—Forty-four products recovered in recycling an automobile.

The Bureau has found that plastics (after sorting by a sink-float process) could be combined with other plastics to make new styrofoam, and polyvinyl chloride could be used as an easily tranported source of hydrochloric acid (an important industrial chemical). The Ford Motor Co. and General Motors Corp. joined the Bureau in this plastics reuse effort, because modern automobiles contain huge amounts of plastic (200 pounds or more).

Municipal wastes

The Bureau, extending its work on the recovery of metals from auto carcasses, began seeking economic methods to recover metals from municipal wastes in fiscal year 1966. The city dumps of the United States were estimated to contain some 5 million tons of iron (mainly "tin" cans), and ½ million to 1 million tons of nonferrous metals.

In fiscal year 1967, working with residues from a Maryland incinerator, the Bureau was attempting to recover and reuse economically the discarded metals in unburned residues. Sampling and separation methods had been explored in the laboratory, and the feasibility of scale-up operations was being investigated.[77]

Several years before 1972 the Bureau had built a pilot plant at its College Park (Md.) experiment station, and showed that it could reclaim most of the mineral values in household trash from municipal

[77] It was estimated that in a typical year, the unburned residues from the municipal incinerators in the United States contained 3 million tons of iron and 200,000 tons of aluminum, copper, zinc, and other nonferrous metals. These incinerator residues, many of which are richer than workable ore deposits, were being plowed into the ground at dumps and landfills.

incinerators. The incinerator ashpits contained 50 percent glass by weight, and 30 percent metals; all of these residues were recovered and converted into industrial raw material (figs. 13–14). The economics also appeared to be favorable, so in 1972 the city of Lowell, Mass., began building a full-scale, automated recycling operation of its own, using the Bureau's process, but it was never completed.

The value of the 1,820 tons of nonferrous metals and the 19,825 tons of recyclable iron, and the 30,875 tons of glass and the 200,000 tons of paper and plastic in a year's trash in Lowell was estimated to be $1.8 million. With annual operating costs estimated to be $500,000, the annual profit of a recycling operation should be approximately $1.3 million if markets for the trash could be developed. Glass and plastic were being discarded because they could not be made into marketable products, but Bureau researchers found that waste glass could be recycled into commercial-quality bricks, floor tile, and mineral wool.

FIGURE 13.—Recycling plant for treatment of municipal waste for recovery of metals, papers, glass, and plastics.

FIGURE 14.—Kinds of materials recovered from municipal waste-recycling plant.

Mine and mill wastes

The Bureau was continuing its investigations in fiscal year 1967 to recover ceramic materials from the "red mud" wastes of alumina plants, and to make structural materials from mine and mill residues. As part of this program the Bureau awarded numerous contracts and grants to universities and other organizations, for research on the re-use of mineral wastes.

In 1974, building bricks that met commercial specifications were being produced from tailings [78] from copper and zinc mills. After being dried, crushed, and mixed with a bonding material such as cement, these tailings were molded into bricks and then steam-cured.

Phosphorus

In fiscal year 1965, the Bureau was working to develop a process to extract profitably the phosphorus contained in low-grade shales in the Western United States, but it did not prove economically feasible. The process, if successful, would double the U.S. phosphate reserves, which are the source of the phosphate fertilizers that are sorely needed to restore fertility to croplands in many parts of the world.

Silver

The Bureau developed a technique in fiscal year 1966 using inexpensive steel wool to recover silver from used photographic film-fixer solution. The process was seen to have commercial possibilities in a small business operation similar to a water-softening service.

[78] Tailings—waste material resulting from the processing of ores.

Brines

The Bureau has developed a flotation process for upgrading crude potash-containing evaporates so that they are satisfactory for further processing to fertilizer materials. This process is now being adopted by a commercial firm for application to low-grade Great Salt Lake evaporates. Potential commercial application for the recovery of magnesium, potassium, and perhaps lithium from Great Salt Lake is strongly indicated.

Zinc

During 1973 the price of zinc increased significantly. Although much zinc was being wasted in dusts from the gases generated by electric steelmaking furnaces, no economical method had been devised to recover the 100,000 tons of zinc lost each year in the United States in this manner, creating air pollution during transportation and storage, and causing water pollution when washed into streams. Bureau researchers attempted to develop a process that would recover the zinc from the dust. Laboratory tests showed that more than 90 percent of the metal could be recovered, and that the manganese and iron could be recycled under certain conditions. The process has been not applied commercially yet.

Carbon black

Until fiscal year 1966, all commercial carbon black had been obtained from petroleum or natural gas. In that year, however, as a spinoff from a process to make hydrogen cyanide by reacting coal with ammonia, Bureau scientists discovered that carbon black was being produced as well, in amounts that were potentially economic. This type of carbon black, called thermal black—which was used to improve the quality of consumer items ranging from tire sidewalls to floor tile—has a market of 100,000 tons annually. Bureau scientists determined that coal could be used to replace petroleum in the manufacture of synthetic graphite.

Uranium

In fiscal year 1967 the Bureau began a cooperative pilot test with industry, using a new Bureau process to recover uranium from solutions that leach copper from a large low-grade copper deposit. In fiscal year 1968 the completed tests showed that the application of the Bureau process to waste solutions at domestic copper operations could be expected to yield about 2,000 tons per year of uranium oxide, plus substantial amounts of yttrium (a rare-earth element used in electronic equipment).

Engineering, evaluation, and demonstrations

River basin activities

In fiscal year 1962 the Bureau evaluated the mineral resources in the 11,000 square-mile Rampart Reservoir site (Alaska).

Surface mine reclamation

The Bureau began, in fiscal year 1963, to develop techniques and patterns for returning strip-mined lands to recreational areas and other uses.

In fiscal year 1966 the Bureau reached the halfway mark in its investigation that has been authorized by the Appalachian Regional Development Act of 1965, with the completion of a report on past surface- and strip-mining in Appalachia and its effects on streams, fish, and wildlife, and urban development. The study, conducted in cooperation with other Federal, State, and local organizations, was the first phase of a nationwide investigation of the reclamation and restoration problems resulting from such operations. The Appalachian study noted that the cost of even a minimum reclamation effort would be $250 million.

In mid-1967, Interior Secretary Udall issued the report required by the Appalachian Regional Development Act of 1965, which called for an evaluation of the nationwide effects of surface mining, and recommendations for corrective action. Several Interior Bureaus and half a dozen other Federal agencies had provided experts, and the various States had appointed liaison officers to work with the Federal task force being coordinated by the Bureau of Mines, with participation by municipalities, industry, and citizens' groups. The study showed that every State had been affected by surface mining, that two-thirds of the 3 million acres so disturbed were still in need of reclamation work—mainly to preserve water quality in the streams, and that less than one-third of the land that was being surface-mined each year was being properly reclaimed.[79] Federal standards for surface mining and land reclamation were proposed by Secretary Udall, as guidelines within which each State could establish adequate controls. The "Surface Mining Reclamation Act of 1968," proposed by the administration with the endorsement of President Johnson was before the Congress.[80]

Surface-mine reclamation projects in fiscal year 1967, operated cooperatively by the Bureau and the Commonwealth of Pennsylvania, included two for reclaiming coal surface-mined lands. In fiscal year 1968 Bureau engineers and those from the Commonwealth of Pennsylvania under the auspices of the Appalachian Act devised a plan to restore 200 blighted acres—scars from past surface mining—so they would be as attractive as the rest of the 3,200 acres of Pennsylvania's Moraine State Park.

By 1971, some 28 States had enacted surface-mining legislation—20 of them since 1966. Although there was underground mining in 39 States, only 3 had laws regarding the control of subsidence. The administration recognized that "some Federal regulation of mining activity is needed," (1) to insure that all 50 States regulate mining according to equitable national principles, (2) to prevent environmental deterioration from all types of mining, and (3) to make environmental protection an accepted part and cost of mining activity.[81]

Water problems of the mineral industries

In fiscal year 1956 the Bureau began studying the water problems of the mineral industries, especially (1) the water quality required by the processing plants and (2) the mineral constituents of waterborne wastes.

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[79] USDI, "Surface Mining and the Environment": Special Report of the Secretary of the Interior, 1967, 124 p. (especially pp. 39, 42).

[80] But neither it nor other such legislation introduced since then has been passed by the Congress.

[81] Statement of Hollis M. Dole, Assistant Secretary of the Interior for Mineral Resources: Hearings on Pending Surface Mining Legislation, Senate Committee on Interior and Insular Affairs, Nov. 16, 1971: 92d Cong. 1st sess., serial No. 92-13, pt. 1, 1972, pp. 184-199.

In fiscal year 1958 the Bureau surveyed the water needs of the major mineral-processing plants in the Salt Lake drainage basin, and in fiscal year 1962 its study of the water requirements of Arizona's mineral industries was completed.

Wilderness areas

Jointly with the U.S. Geological Survey, the Bureau began in fiscal year 1965 to assess the mineral potential of areas being considered for inclusion in the National Wilderness Preservation System that had been established by the Congress in 1964. (For the current situation, see p. 145)

Acid-Mine drainage

In fiscal year 1966 the Bureau, in cooperation with the Federal Water Pollution Control Administration, the Bureau of Sport Fisheries and Wildlife, and the U.S. Geological Survey, investigated effective methods for controlling the acid-mine water that pollutes fresh-water sources in many coal-mining areas of Appalachia. Three projects were underway in West Virginia, and one in Pennsylvania.

Mine waste piles

The Bureau attempted in fiscal year 1967 to solve the problem of refuse from mines and mills in a couple of ways—(1) to make plants grow on waste piles, so as to increase their resistance to erosion by wind and water, and (2) to pump wastes back underground into abandoned mine voids.

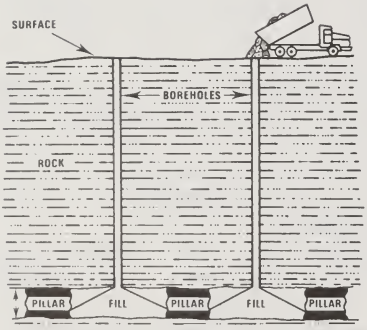
Subsidence

Two mine-subsidence projects were completed in fiscal year 1965, using material from old culm banks to fill underground mine voids and thus prevent subsidence. Two similar projects were planned for the Pennsylvania anthracite region, to be conducted under the Appalachian Regional Development Act.

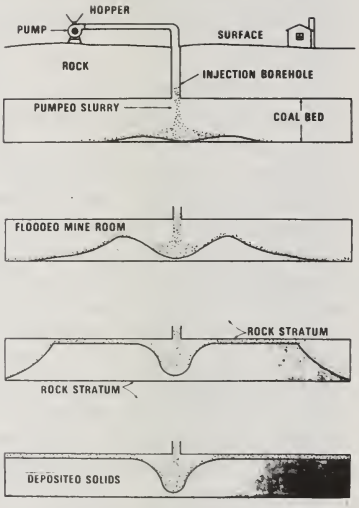
The Interior Secretary approved two subsidence-control projects in Pennsylvania in fiscal year 1966—the first such undertakings to be proposed by a State under the Appalachian Regional Development Act of 1965. These projects, 25 percent paid for by the State, would protect approximately 2,000 homes and numerous public buildings having a total estimated value of $50 million.

Two years later, three such projects were under way, costing $2.3 million; they were estimated to benefit 14,000 people and protect property valued at $38 million.

The Bureau had been involved in projects on the backfilling of abandoned mine voids since they were first authorized by the Congress in 1962—by flushing fill material down holes drilled from the surface. In 1972 the Bureau began experimenting with a new technique, pressure-flushing, under a contract with the Dowell Division of the Dow Chemical Co. (Because of the pressure, instead of a cone of material building up at the bottom of the drill hole, a doughnut of fill is formed, which continues to distribute the material horizontally as the mine opening is filled to the roof so it ultimately provides support for large areas underground.) It was successfully field tested in an abandoned mine at Rock Springs, Wyo., and then was given a full-size test in Scranton, Pa.; the latter project was successfully halfway to completion at the end of 1972. (figure 15).



TYPICAL SECTIONS SHOWING BOREHOLES AND CONFIGURATION OF FILL MATERIAL PLACED IN MINE VOIDS BY THE GRAVITY BLIND FLUSHING METHOD



SECTIONAL VIEWS THROUGH A FLOODED MINE ROOM AT THE POINT OF SLURRY INJECTION SHOWING MOVEMENT AND GROWTH OF FILL

U.S. BUREAU OF MINES

FIGURE 15.—Mine waste, injection into underground mine as a slurry.

Underground fire control

In fiscal year 1960, Bureau research was completed on the control of mine fires in active underground mines by using high-expansion foam.

The Bureau completed 22 fire-control projects in fiscal year 1965, continued efforts on 9, and planned 19 new ones (12 to be carried out under the Appalachian Regional Development Act).

The Interior Secretary approved seven mine-fire control projects in Pennsylvania in fiscal year 1966—the first to be proposed by a State under the Appalachian Act. These, together with the three subsidence projects mentioned above, would cost $13 million, but would protect property valued in excess of $50 million, would safeguard the lives and health of hundreds of thousands of people, and would provide some 1,300 man-years of employment in an economically depressed area.

During fiscal year 1967, 12 fires in abandoned coal mines were attacked by the cooperative Federal-State projects, costing $11.5 million. At the end of the year, 3 fires had been controlled and the other 9 were still active—including 2 large and dangerous fires near Scranton and Wilkes Barre, Pa. Completion of these projects would benefit more than 300,000 people, and protect public and private property valued at $650 million.

The Scranton fire-control project was well underway during fiscal year 1968, but only after many months of hard work and cooperative effort by local, State, and Federal agencies. Control plans had to be carefully engineered, rights of way and other legal permits had to be obtained, and local sources had to find and provide needed materials (sand, slag, fly ash, etc., that are injected through bore holes or back-filled into the trenches into old mine workings to control the fire). Cooperation of individual citizens involved real sacrifice—for example, at Scranton some 55 families had to evacuate their homes, some because of noxious fumes from the burning coal seams, and others so the control work could proceed.

This particular fire-control effort eventually required a trench nearly half a mile long, 135 feet deep (eventually it was deepened to 190 feet), and 30 feet wide at the bottom, which was to be filled with noncombustible material (sand) so as to create a fireproof barrier that would isolate the fire from the populated area (fig. 16). Eventually, some 2.6 million cubic yards of material was moved, and the land surface regraded to its normal contours and the trench filled. In addition to supplying the material for the fire barrier, the city was supplying millions of gallons of water to wet down and cool the burning coal exposed as the trenching progressed. The State paid 25 percent of the project's total cost—which was to be about $4.5 million. In 1970 the project was completed—after 4 years and more than $5 million cost. The fire, which had begun in 1966 in an abandoned strip mine pit, had burned its way into abandoned mine tunnels; late in 1966 dozens of families had to be evacuated because deadly carbon monoxide gas began seeping upward from the fire into the basements of homes in the neighborhood. The total cost of nearly $7 million included $1.5 million to compensate owners of condemned property who had to be displaced for the construction of the man-made canyon. Coal valued at about $90,000 was mined from the fire site, to help defray part of the cost.

FIGURE 16.—Underground coal fire, start of trench excavation.

In fiscal year 1969, eight new projects to control fires in abandoned coal mines were completed, through cooperative efforts with State and local agencies. These would benefit 70,000 people and safeguard public and private property valued at $288 million.

Mineral data and analysis

Minerals policy

The Mining and Minerals Policy Act of 1970 (approved December 31, 1970) requires the Interior Secretary to keep the Congress informed of all important developments affecting the domestic minerals industry, and to recommend legislative programs needed to implement the act. The Congress declared, in passing the act, that "it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in developing America's mineral resources and industries, and in combatting the environmental effects of mineral wastes and mining." [82]

Strategic minerals

The Bureau produced seven mobilization-planning reports for the Office of Minerals Mobilization in fiscal year 1958. The Bureau helped the Office of Defense Mobilization develop data for the special Stockpile (Pettibone) Advisory Committee's report, "Stockpiling for Defense in the Nuclear Age."

[82] "Indivisibly One," U.S. Department of the Interior Conservation Yearbook Series, No. 8, 1971, pp. 18–19.

Minerals yearbook

In fiscal year 1965 the Bureau added a separate, international volume to its annual *Minerals Yearbook*, containing reviews of mineral-resource and mineral-industry developments in 130 countries and areas throughout the world. Previously, such statistical material had been included in volume I of the *Minerals Yearbook*, and descriptions of foreign developments in *Mineral Trade Notes*.

III. Present Program of the Bureau of Mines [1]

A. GENERAL STATEMENT

The Bureau of Mines is the Federal Government's agency to assess and develop technology for mining and mineral processing, and for the gathering, interpretation, and publication of information on the statistics and economics of minerals and fuels production, consumption, and trade. (fig. 17.) Bureau specialists work closely with counterparts in industry, union, universities, and research and development organizations, both in the United States and abroad.

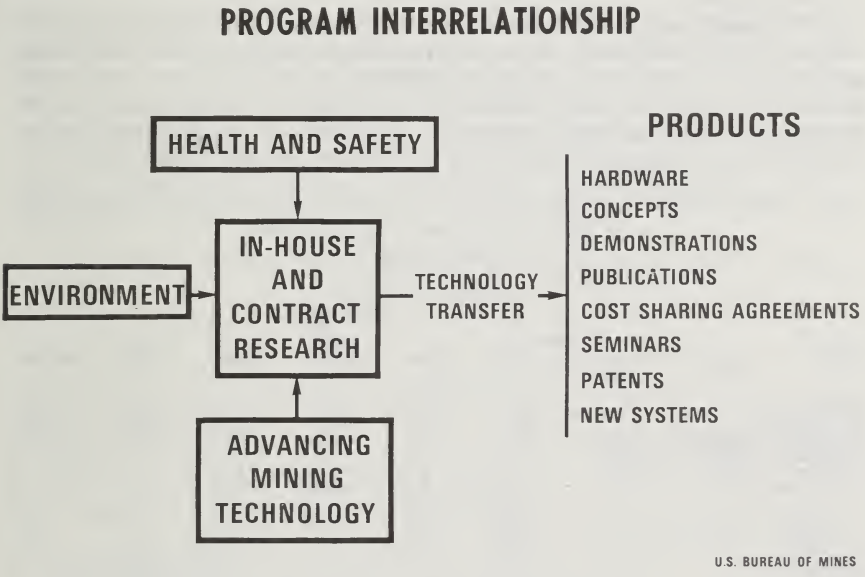


Figure 17.—Program interrelationships, Bureau of Mines.

A large part of the Bureau's work is directed toward mining research, covering all phases of the technology of the extraction of minerals and solid fuels, including economics, productivity, mine health and safety, and environmental considerations. Coal mining receives special attention, as does mined land reclamation and land subsidence in anthracite areas.

Metallurgical research in the Bureau is focused on improving the extraction, processing, use, and recycling of metals and nonmetals. Emphasis is placed on methods to upgrade U.S. resources of minerals containing aluminum and titanium, which must be imported in large amounts, and to discover ways of producing certain elements such as copper in ways that are environmentally more suitable then at present.

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[1] Taken largely from the Budget Justification for the Department of the Interior and Related Agencies for fiscal year 1976, Senate Appropriations Committee: *U.S. Cong., 94th, 1st sess., pt. 1, 1975*, pp. 607–711.

The main source of statistics on minerals and fuels—their production, consumption, prices, trade, etc.—is the Bureau of Mines, which gathers the data that are supplied voluntarily by industry and publishes them at regular intervals. This information provides the basis for the Secretary's annual report on the Mining and Mineral Policy Act of 1970, and for numerous Bureau of Mines analytical and interpretive economic studies.

Hundreds of Bureau publications—technical as well as economic—are issued annually, which are used by planners and policymakers in industry and in several entities of the Federal Government as a reliable source of essential domestic and foreign data.

The Bureau operates the Federal Government's helium-conservation program.

The budget request of the Bureau of Mines for fiscal year 1976 places greater emphasis on metallurgical research, and on collecting and analyzing information about mineral supply and demand, with increases over fiscal year 1975 of 34 percent and 17 percent, respectively. The total amount requested was $143.4 [2] million, which was $9.6 million (7 percent) more than in fiscal year 1975 (See Table 2).

TABLE 2.—BUREAU OF MINES BUDGET FOR FISCAL YEAR 1976, COMPARED WITH FISCAL YEAR 1975 AND AS CHANGED BY THE HOUSE AND SENATE AND CONFERENCE

[Dollars in millions]

	Fiscal year 1975	Request	Fiscal year 1976 percent change	House passage	Senate passage	Conference
Metallurgy	$20.1	$27.0	+34.0	$26.4	$25.8	$26.1
Mining research	89.7	91.0	+1.5	[1] 105.8	104.3	100.8
Data collection and analysis	12.4	14.5	+17.0	13.6	13.3	13.4
Engineering, evaluation and demonstration	10.0	9.5	−6.0	[2] 10.9	9.6	12.4
Administration	1.5	1.4	−10.0	1.25	1.25	1.25
Total	133.8	143.4	+7.0	142.9	154.2	154.0
GSA space	[3]	[3]		[4] 2.3	2.3	2.3
Pay increase	[3]	[3]		1.4	1.4	1.4
New personnel					−0.3	−0.3
Total	133.8	143.4		146.6	157.6	[5] 157.4

[1] Includes $1,500,000 to establish a mining research center at Southern Illinois University, Carbondale, Ill.; also $15,000,000 for coal mining research requested by the Bureau as a supplement.
[2] Includes $2,000,000 for mine land investigations and demonstrations in the (Pennsylvania) anthracite area.
[3] Distributed among 5 program elements.
[4] Decrease from fiscal year 1975 of $250,000.
[5] Public Law 94-165, signed by the President, Dec. 23, 1975.

The Bureau's mining research activities would be assigned most of the dollars ($91 million, an increase of only $1.3 million, or 1.5 percent over fiscal year 1975), which would be spent on mining technology from the standpoint of health and safety, on environmental control, and on productivity.

Metallurgical and mineral-processing research would get $27 million (a 34 percent increase), to be used for improving the U.S. position regarding strategic and critical minerals, and for adapting the advanced smelter-gas cleanup technology to coal-burning powerplants.

[2] The House-passed appropriations bill July 23, 1975, increased the total number to $146.6 million, by adding $2.3 million for rental of GSA space and $1.4 million for a pay increase. *Cong. Rec.* July 23, 1975, pp. H7271-7326. Also see *U.S. Cong., 1st sess., House Rept. 94-374*, July 18, 1975, pp. 30-31.

Collecting and analyzing technical and economic data on minerals would consume $14.5 million (an increase of 17 percent), and $9.5 million would be spent for engineering, evaluation, and demonstration activities (6 percent less than in fiscal year 1975). Administrative needs were requested to be satisfied by $1.4 million, or 10 percent less than last year.

The energy-conversion research activities that had formerly been conducted by the Bureau, and funded at $87.4 million in fiscal year 1975, were transferred in January, 1975 to the new Energy Research and Development Administration, and are not listed in table 2 nor are they discussed herein.

B. MINING RESEARCH

The mining research activities of the Bureau would require $91.0 million in fiscal year 1976, and would consist of two major elements—(1) advancing mining technology and (2) mining health and safety research—as shown in table 3. The budget for mining research has grown from about $5 million in the early 1960's, in response both to the Coal Mine Health and Safety Act of 1969 [3] and to the Nation's need for increased efficiency, productivity, and conservation of U.S. mineral resources.

TABLE 3.—MINING RESEARCH ACTIVITIES BUDGETED BY THE BUREAU OF MINES FOR FISCAL YEAR 1976

[Dollars in millions]

	Fiscal year 1975	Fiscal year 1976	Percent of fiscal year 1976
1—Advancing mining technology:			
Coal	$46.5	$44.5	49.0
Oil shale	5.6	5.6	6.0
Metals and nonmetals	4.7	5.4	6.0
Explosives	.6	.6	.7
Subtotal	57.4	56.1	61.7
2—Mining health and safety:			
Coal mine health research	3.5	3.9	4.3
Coal mine safety research	24.2	25.3	28.0
Metal and nonmetal H. & S. research	4.6	5.7	6.0
Subtotal	32.3	34.9	38.3
Total	89.7	91.0	100.0

Mining research in the Bureau attempts to solve problems that result from mining being one of the most hazardous industries—problems that are keeping the minerals and fuels industries from meeting current and projected U.S. demand for their products. These problems are due largely to five interrelated factors:

—character of the mineral or fuel deposit
—health and safety constraints
—environmental constraints
—energy considerations
—supply-demand relationships and trends

[3] The accident record of metal and nonmetal mines is almost as severe as that of coal mines. For example, in 1975 the industry experience for fatalities showed 0.41 per-million man-hours for coal and 0.27 for metal and nonmetal mines. Nonfatal injury statistics during 1975 were 31.07 and 17.76, respectively, for coal and noncoal. The coal numbers have not improved significantly since the initial drop in 1970–73, the first 3 years of the act's operation, and noncoal mining statistics have likewise improved little in that same period.

Objectives of the Bureau's R. & D. program have been established to meet the Nation's short-term, mid-term, and long-range needs. Bureau of Mines' mining research centers are supplemented by outside contracts with universities, with not-for-profit research organizations, industrial research centers, labor unions, trade associations, and individual mining companies.

A major goal of the mining research program is technology transfer, whereby the Bureau attempts to reduce the 10–20 year lag between development and use of new equipment and practices. These activities include publications, seminars, meetings, and onsite (in-mine) demonstrations.

Advancing mining technology—coal

The Bureau will spend $44.5 million in fiscal year 1976 (or 4 percent less than last year) on 11 subprogram elements, which are described below, to improve U.S. coal-mining technology.[4]

(a) *High-speed mine development.*—The objective is to reduce the time for getting new coal mines into production, and to improve productivity in existing mines. In fiscal year 1976, demonstration of a tunnel-boring machine for main-entry development will near completion, as will the fabrication of equipment for high-speed lining of bored raises.[5] Demonstration of equipment for single-entry [6] longwall development will begin, as will the design and construction of a vertical boring machine for shaft-sinking [7] and field demonstration of a conical boring device for raise boring.

(b) *Automated longwall.*—This subprogram is intended to adapt the longwall mining technique, successful in Europe, to U.S. conditions and to increase its productivity through increased automation. In fiscal year 1976, documentation of state-of-the-art criteria for selection of longwall mining systems will continue, as will the mining of a first demonstration panel using shield-type longwall supports; a second demonstration, to show the applicability of such shields to different ground [8] conditions, will begin. Acquisition and compilation of geologic data from longwall and shortwall panels will continue, being used to define site-selection criteria for longwall mining.

Development of sensors for the coal-rock interface will near completion; they will be applied to the remote operation of longwall-shearing machines. Two facilities that will increase the effectiveness of this research are already well underway—one for roof-support testing and the other, a simulated longwall face for testing equipment.

(c) *Automated remote-controlled continuous miner.*—Continuous mining machines currently operate an average of only 25 percent of each 8-hour shift, because of breakdowns and operational delays. This subprogram is aimed at reducing such breakdowns and operational delays by improving the reliability of the machines, [9] by using continuous roof support and haulage systems (developed by other subprograms),

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[4] Preliminary results of an evaluation of the subprograms by the MITRE Corporation shows that they would achieve Benefit/Cost ratios ranging from 9.7 to 65.0 and having an overall B/C of 16.7; this matter is being re-examined by the Bureau.

[5] Raise—a mine shaft driven upward from below.

[6] Entry—an underground passage used for haulage, ventilation, or as a manway.

[7] Shaft—a vertical or nearly vertical narrow opening from the surface down into an underground mineral deposit, for lifting rock and/or lifting and lowering men and equipment, and for ventilation.

[8] Ground—as used by miners, any part of a mineral deposit or the rock material being mined; not the surface of the earth.

[9] A study, initiated in fiscal year 1975, has identified mechanical, hydraulic, and electrical weaknesses, and attempts will be made to correct these.

and by increasing the machine's capacity through automation. Development of automated controls is tentatively scheduled for fiscal year 1978.

(d) *Continuous face-to-preparation plant coal haulage.*—The objective is to improve haulage systems between the mine face and the surface preparation plant—because transportation of coal, men, and supplies is a major bottleneck in underground mining operations, and hampers productivity. Development and testing will proceed on continuous hydraulic transportation of coal underground, on improved face [10] and mainline belt conveyors, and on automated underground rail haulage. This will be funded partly by the Bureau's coal mine health and safety program.

(e) *Automated continuous roof support.*—A significant factor that causes delays in room-and-pillar mining is the installation of roof supports. The Bureau hopes to solve this problem (1) by mounting roof bolters on continuous miners, and (2) by constructing a remote automated roof bolter for operation in conjunction with the automated continuous miner being developed (see paragraph "c," above). Also, a new system for roof control during pillar removal will be demonstrated—which will enhance safety as well as productivity.

(f) *Mining systems for Western coal.*—This subprogram's goal is to develop new methods, or adapt existing ones, which will permit full extraction of the coal-mining systems from thick and multiple coal seams. Underground coal-mining systems used by the American mining industry are not suited to this task. [11] However, thick-seam mining is common in Europe, so appropriate European practices that have been selected by a study that began in fiscal year 1975 will be tested in the Western United States.

(g) *Environmental protection of surface areas near underground mining operations.*—Many surface environmental hazards are associated with underground mining. In fiscal year 1976 work will continue on three such subjects, initiated last year: (1) prediction and control of mine subsidence, (2) prevention of the formation and release of contaminated mine drainage, and (3) disposal of solid and liquid wastes from mines and preparation plants.

(h) *Methane recovery from unmined coal and from gob* [12] *areas.*—In order to stimulate commercial production of pipeline gas from coal, while at the same time improving the safety of future operations, the Bureau will drill a production pattern of wells in two coal beds. (The first area will contain a multibranch directional-drilled hole.) Potential gob sites will be selected to demonstrate the production of methane from such areas, and the same selection procedure will be used for coal beds that have methane-production potential.

(i) *Advanced mining systems.*—Seeking increased productivity, greater utilization of resources, improved health and safety, and

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[10] Face—the end of the mine opening, where mining is being done, or was last done.

[11] A couple of alternative recommendations are made in an interesting paper presented during the Society of Mining Engineers' Fall meeting Sept. 10-12, 1975. Entitled "An Evaluation of Underground Mining Technology for Western Thick Coal Seams," C. J. Bise and R. V. Ramani of the Pennsylvania State University recommend that, for moderately dipping thick seams, a continuous miner with side-mounted roof bolters be combined with a chain conveyor—extensible belt system, as in India. For tabular, thick seams they propose the French integrated longwall method (SME Preprint No. 75-F-341, pp. 17-20).

[12] Gob—material (especially waste or low-grade coal or metallic ore) which is stowed underground as part of the process of selective mining; sometimes applied in surface mining, but "spoil" is a more common term there.

enhanced environment, the Bureau is developing (1) a hydraulic borehole mining method for steeply dipping coal beds or those that are too deep or too thin to respond to conventional extraction methods, (2) underground hydraulic jet miners using high-volume low-pressure water jets, (3) underground coal haulage for strip mines, and (4) several kinds of underground augers. Field demonstrations are planned for fiscal year 1977. A simulated underground mine will be built on the surface at the Bureau's Bruceton, Pa., facility.

(j) *Improved surface mining systems.*—The objective of this program element is to develop more productive and environmentally acceptable surface-mining and reclamation techniques. Particular emphasis is placed on the development of a rationale for integrated mining and reclamation planning, on the development and engineering evaluation of designs for improved overburden handling techniques, mine layouts, and highwall reduction, and demonstration (cooperative and/or cost-sharing) of improved surface mining and reclamation technology.

(k) *Surface mining equipment development.*—Complementary to the surface-mining systems subprogram, this effort will provide the equipment necessary for that one. Overburden-removal[13] and spoil-handling[14] elements are keys to efficient and economic surface mining and reclamation, but present equipment is not designed specifically for reclamation to the original contour of the land. Thus, improved equipment will be tested, including specially designed dozers and winch-assisted dozers.

Special studies will include research on improved coal-preparation techniques for reducing the sulfur and ash content, on the washing and dewatering of finely divided coal, and the treatment of low-rank Western coals to reduce the moisture content and improve the handling and shipping characteristics. In addition, special studies to enhance mined-land reclamation through developing processes of restoring spoil banks and mined areas will be carried out in both the Eastern and Western United States.

Advancing mining technology—oil shale

The oil shale advanced mining technology program, which will take $5.6 million, the same as last year (table 3), consists of two elements—(1) extraction, and (2) waste management. In fiscal year 1976, preparations for the sinking of the 20-foot diameter shaft[15] near the center of the Piceance Basin, Colo., will be continued; as geologic and hydrologic studies are completed, the site will be selected, and specifications for the shaft will be prepared.

Waste-management studies, begun last year, will continue on disposal in the mine, on waste-bank stability factors, on waste-material characteristics, and on vegetative and artificial stabilization techniques.

Advancing metal and nonmetal mining technology

The Bureau's Metal and Nonmetal Mining Technology program, which is expected to take $5.36 million in fiscal year 1976 (or a 13-

[13] Overburden—material that overlies a deposit on coal or ore, especially those that are mined by open pits.
[14] Spoil—debris or waste material from a coal mine, which is cast aside in the surface-mining process.
[15] This shaft will provide an underground laboratory for specialists to investigate ground-water problems, to perform stress measurements, and to begin the testing of new mining methods and equipment that are suited to the deeper parts of the western United States oil shale deposits.

percent increase over last year), consists of four elements: (1) premining investigations, (2) underground mining, (3) surface mining, and (4) in-situ mining. As with the coal mining-technology program, the metal and nonmetal technology program has projects that are aimed to solve problems in three different time frames—immediate, midterm (3–5 years), and long range.

Premining investigations will include the study of surface microwave systems for shallow geophysical systems, the evaluation of techniques for between-borehole seismic exploration, and the potential applications of geophysical in-situ assaying techniques.

Underground mining's progress will come, the Bureau believes, from the development of new or improved systems or equipment. A recent analysis of underground metal and nonmetal mines showed that a major factor affecting productivity and efficiency was the handling of ore, of men, and of materials. To improve these underground mining systems, the Bureau plans to:

(a) Develop a portable underground hoist for servicing ore-production areas;

(b) Upgrade the design and efficiency of ore-transfer chutes and storage bins;

(c) Perform numerous block-caving investigations;

(d) Study the use and handling of waste materials for backfilling, as is done in the deep vein mines;

(e) Develop and apply rock-engineering design criteria for mine openings, develop analytical techniques for modeling gross behavior of mine openings, and initiate the development of deep-hole stress-measurement systems;

(f) Improve the utilization of current drilling and blasting equipment, as the most cost-effective way to solve the problem of inefficiencies in ore production caused by the cyclic nature of drilling and blasting operations, by analyzing innovative blasting practices;

(g) Perform research on improved cutter design, a critical need for hard-rock mining particularly, and investigate continuous drill-blast concepts;

(h) For secondary breakage, small portable breaker units are needed for hard materials, and new techniques (such as thermo-mechanical) will be incorporated in equipment design; and

(i) Future trends in the mining industry will be investigated, to identify potential problem areas for existing technology as a result of anticipated stronger environmental and land-use regulations, and health and safety standards.

Surface-mining technology has become more cost-effective because of recent advances that have achieved economies of scale. Encroachment on mining and quarrying operations by urban development, and vice versa, has resulted in public pressure for the regulation and control of blasting in such operations. In the past, the Bureau has established ground-vibration thresholds that are applicable to residential buildings; the problem that will be addressed now is that of noise-level measurement (including the determination of the effects of airblast generation and propagation) and determination of damage thresholds for airblasts.

In surface-mine design, because pit-slope angle has a critical effect on profitability, such research done by civil engineers in highways and earth dams will be compiled and made available to mine operators.

In addition, as an alternative to reduction in slope angle, Bureau engineers will evaluate the cost-benefit aspects of slope stabilization and support.

In-situ mining systems, which offer the possibility of extracting minerals that cannot now be extracted economically by conventional methods, will be approached by research on:

(a) Solution mining—dissolving the minerals in place, leaving a cavity in the host rock;

(b) In-situ leaching (or selectively leaching) of a mineral from an insoluble host rock; and

(c) Bore-hole hydraulic mining.

In addition, demonstration activities will continue on fragmentation methods for in-situ leaching in copper deposits of the southwestern United States, and research on the leaching process in uranium deposits will continue to define permeability patterns, well-bore design and spacing, and environmental control.

Explosives

The explosives mining technology element will continue with a 7-percent increase, with $645,000 requested for fiscal year 1976 by the Bureau. In this work the Bureau will:

(a) Continue to test new permissible explosive formulations for the Mining Enforcement and Safety Administration;

(b) Devise new schedule tests for fire extinguishers, detonators and detonating cord, and for the applicability of the air-gap test to water-gel explosives;

(c) Continue to evaluate the comparability of new explosive formulations that would be used in rock fracturing during oil and gas operations; and

(d) Expand the analysis of hazards of detonating cords and of initiation factors and systems, and the methods of locating undetonated explosives.

In addition, basic research on detonation growth and decay will be continued, with emphasis on large-scale projectile impact.

Health research—coal mines

Health research in the coal-mining environment in fiscal year 1976 would receive $3.9 million, a 12 percent increase over last year.

Greater emphasis will be placed on reducing the level of respirable dust (the cause of black-lung disease) in mine environments. This will involve the control of dust-generation by modifying machines, by advances in ventilation, and by more efficient application of water. Dust collectors that were developed during fiscal year 1975 will be evaluated and demonstrated in underground situations.

Regarding the mandatory noise standards that were promulgated under the Coal Mine Health and Safety Act of 1969, because most noise sources in underground mines are intermittent, measuring the exposure of miners is difficult. Research will therefore be directed toward:

—Development of improved instrumentation;
—Reduction of noise in mining machinery; and
—Abatement of noise in surface installations.

Research will continue on defining the toxic decomposition products that result from a number of combustible mine materials (such as conveyor belts, cable insulation, and brattice [16] cloths), and on methods to reduce both toxic [17] and noxious [18] emissions from diesel-powered equipment (by emphasizing control of carbon monoxide, the oxides of nitrogen, and odor) and on instrumentation to detect these emissions.

Safety research—coal mines

Safety research in coal mines is budgeted at $25.3 million in fiscal year 1976, or 5 percent more than last year. The second largest element of the Bureau's coal mining research program (see table 3), it will absorb 28 percent of the budget for that activity in fiscal year 1976. Coal mining technology will take the most, or 49 percent.

Research on fire and explosion will focus on (1) the development and evaluation of instruments to detect and suppress the ignition of methane at the mine face, on (2) establishing alternatives to rock dusting, and on (3) providing data on how coal-dust explosions are initiated, propagated, and extinguished.

In cooperation with industry, the Bureau will continue to work on techniques for plugging abandoned oil and gas wells that penetrate coal beds, so they can be mined through, successfully.

The Bureau's ground-control research program aims at preventing accidents from roof falls underground. A geophysical system for detecting channel sandstones in the roofrock (a hazardous mining condition), before mining, is ready for demonstration for industry acceptance. A handbook of design criteria for safer mine openings is being prepared. The Bureau's project on single-entry development for longwall mining will complete its first longwall panel during fiscal year 1976, with results being made available to industry immediately.

Field evaluations of resin-grouted [19] bolt performance will be expanded, and guidelines prepared for designing roof-control plans for these bolts. Work will continue on the evaluation of new roof-support systems, including field demonstrations, and on the development of substitutes for petrochemical-base resins now used for grouted bolts (and for which the source material has recently become in short supply because of the U.S. petroleum situation).

Remote roof-bolt drilling techniques, selected from prototype systems that were developed during 1975, will be constructed and demonstrated underground, as will safe and easily handled temporary roof-support systems. Seismic roof-fall warning devices will be available, and ongoing research that is scheduled for completion in fiscal year 1976 will establish design criteria for waste embankments.

Bureau research on human factors will continue to emphasize the evaluation of training methods and mine-machine simulators for improving the safety and performance of operators.

Research on improving the power systems and grounding techniques in mines and on methods of maintenance for trailing cables will continue.

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[16] Brattice: partition in the mine, for ventilation.
[17] Toxic: poisonous.
[18] Noxious: harmful to health.
[19] Grout: a thin slurry of cement or other material that hardens in cracks or on a wall or face.

Full-scale evaluations of automatic brakes for rail-haulage systems will be completed, providing guidance for compliance by industry with the Coal Mine Health and Safety Act of 1969.

Underground illumination criteria will be pursued, and improved lights will be developed and evaluated in the mines.

Research to improve communications and the monitoring of critical mine factors will be continued, including the testing and demonstration of an advanced system (designed in fiscal year 1975) in a small operating coal mine.

Safer haulage and handling methods will be studied, as a continuation of research during fiscal year 1975 (figs. 18–21).

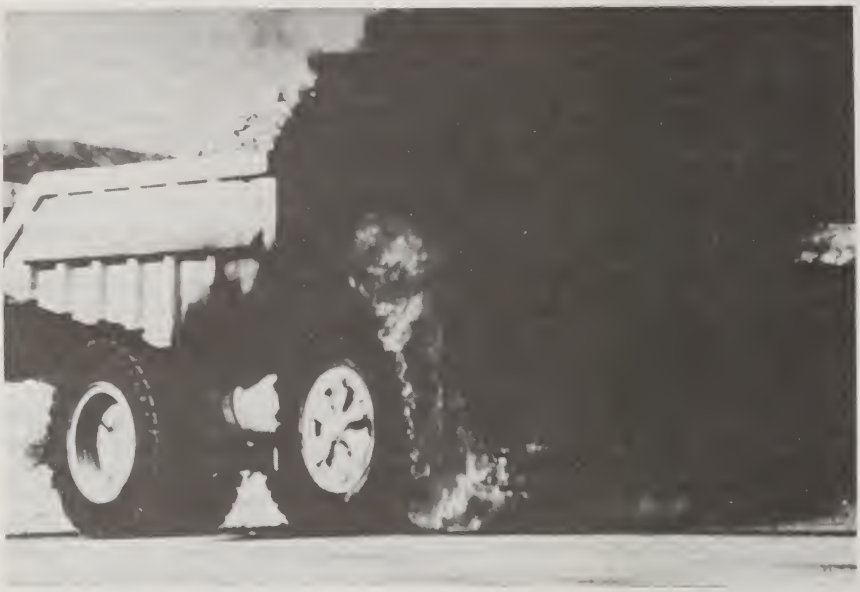

FIGURE 18.—Typical fire on a large-capacity, unit-rig truck.

FIGURE 19.—Same truck, fire extinguished.

FIGURE 20.—"Nonflammable" conveyor belts are not always nonflammable.

FIGURE 21.—Innovative design of large shuttle car for coal haulage in underground mine with low roof.

Research will be continued to develop improved oxygen sources for escape-breathing apparatus; to determine the metabolic requirements of mines during an emergency; to develop a cooling vest, helmet, and breathing apparatus for rescue-team members; and to improve methods for detecting, locating, and communicating with trapped miners, and methods for assessing the underground environment through boreholes.

For the long range, development of new and advanced mining systems that are inherently less hazardous is expected to supply the most significant advances. Particular emphasis will be placed on a new continuous mining system and on hydraulic transport systems. Construction of a test facility for the latter will be initiated. Large equipment problems will be investigated, with the objective of safer design with regard to maintenance and servicing.

Metal and nonmetal mining health and safety research

Research activity in metal and nonmetal mining health and safety activities is expected to consume $5.7 million in fiscal year 1976 (23-percent increase over fiscal year 1975). Bureau activities are programed to include:

—development of a personal dosimeter, to measure the uranium miner's exposure to radiation;
—technology to reduce concentrations of respirable dust to acceptable levels;
—implementation of noise-control measures for underground diesel equipment and drill jumbos;
—testing of instruments for monitoring toxic effluents from diesel exhaust, to be tested in several operating mines;

—continued development of systems to provide fire protection on surface-mining equipment;
—establishing basic knowledge on timber fires and methods to extinguish them;
—completion of analysis of stability of mine structures underground which (along with other rock-burst studies) will provide guidelines for modifying deep-vein mining methods; demonstration of hazard-detection systems for warning of imminent rock falls; the microseismic system for slope-failure warning will be completed, and made available for industry;
—demonstration of techniques for detecting abandoned mine workings;
—continued design and performance-criteria studies for roll-over and falling-object protection, to upgrade regulations and standards;
—establishing a data base for designing a wireless voice-communication system, by collecting data on signal propagation and noise in mines representing different geologic conditions; a system will be manufactured and demonstrated in a room-and-pillar mine;
—reduction of haulage and hoisting accidents, including methods to design, maintain, and inspect hoist ropes;
—continued testing of the electromagnetic method for detecting trapped miners less than 1,000 feet deep in mines having different geologic characteristics, and a system for miners more than 1,000 feet deep;
—building and testing a production version of a hoist radio-communications system for mine shafts as much as 10,000 feet deep; and
—research on the feasibility of improved systems for the mining of irregular vein-type deposits, one of the most hazardous mining processes.

C. METALLURGY RESEARCH

Metallurgical work has been an integral part of the Bureau of Mines program since its formation in 1910, when the Congress established "a bureau of mining, metallurgy, and mineral technology." The general purpose of the Bureau's metallurgical program is to help improve the U.S. minerals and metals posture. Research and development are directed toward providing the scientific and technical information necessary to encourage the nonfuel minerals industry to produce an adequate and continuing supply of mineral raw materials—at acceptable costs for materials and energy, and with a minimum of waste and environmental degradation.

The metallurgy program also reflects the congressional statement known as the Mining and Minerals Policy Act of 1970,[20] wherein it says:

* * * mineral and metallurgical research, including the use and recycling of scrap to promote the wise and efficient use of our natural and reclaimable mineral resources * * *.

[20] Public Law 91-631, "Introduction," pp. 1-8.

The need for research in this area is stressed by U.S. Geological Survey Professional Paper 820,[21] which says that the Nation is in excellent shape for the long term for only a handful of mineral commodities—evaporite salts, gypsum, sulfur, and molybdenum. For a few others—asbestos, chromium, fluorine, and mercury—the United States has only "scant reserves." However, for most of the other mineral commodities, the USGS report emphasizes that the Nation's ability to meet projected needs to the end of the 20th century will depend largely on a number of factors, including the development of new technologies for extracting lower grade ores, and on recycling and conservation in mineral production and use.

Through the years, the Bureau's metallurgy activity has had financial support and cooperation from industry and other Federal Government agencies (such as the Atomic Energy Commission and the Department of Defense). Although the metallurgy program is designed primarily to meet long-term national needs, it is also concerned with current problems of broad scope. In addition, the metallurgy program applies Bureau of Mines' expertise to energy-related research as an extension of its minerals-processing and materials efforts.

The metallurgical activities of the Bureau were estimated to require $27 million for fiscal year 1976.[22] The nine elements of the fiscal year 1976 budget are shown in Table 4.

TABLE 4.—METALLURGICAL RESEARCH ACTIVITIES BUDGETED BY THE BUREAU OF MINES FOR FISCAL YEAR 1976

[In millions of dollars]

Activity	Fiscal year 1976 estimate	
	Amount	Percent
1. Advancing minerals technology	$10.3	38
2. Desulfurization of stack gas	5.3	20
3. Effecting pollution abatement	2.4	9
4. Secondary resources recovery	2.1	8
5. Minimizing mineral and metal needs	2.9	11
6. Alumina pilot plant	2.0	7
7. Uranium ore processing	1.1	4
8. Geothermal	.5	2
9. Energy use patterns	.3	1
Total	26.9	100

Advancing minerals technology

The wide range of mineral and metal commodities required by an industrialized economy such as that of the United States differ in their occurrence and methods of processing. As higher grade deposits become depleted, recovery processes become increasingly more complex. The $10.3 million that is budgeted for this activity of minerals technology (10 percent more than last year) is being spent on investigations of aluminum, nickel, cobalt, gold, and silver, copper, titanium, iron, lead and zinc, phosphate, and on the recovery of important metals from secondary sources (recycling).

[21] Brobst, Donald A. and W. P. Pratt, "United States Mineral Resources." U.S. Geol. Survey, Professional Paper 820, 722 p.

[22] Including $6.2 million in nonrecurring expenditures for the construction of a citrate process demonstration plant for SO_2 removal and for the design of an alumina-from-domestic ores pilot plant. The nonrecurring expenditures in the metallurgy budget increased 9 percent, from $16.2 million in fiscal year 1975 to $17.7 million in fiscal year 1976.

The United States produces 34 percent of the world's *aluminum* metal, but to do so it must import 90 percent of its bauxite [23] raw materials. For a number of years the Bureau and several other organizations have performed research to develop new processes for extracting alumina [24] from low-grade domestic resources that are abundant. In fiscal year 1974 the Bureau initiated a 4-year investigation of several processes for alumina extraction, on a continuous miniplant scale. In fiscal year 1975, 10 aluminum companies entered into cost-sharing cooperative agreements with the Bureau, to accelerate the the program. The miniplant operation will provide data for selecting the most favorable methods for larger scale testing.

Most of the Nation's *nickel* and *cobalt* supplies must be imported because commercial processes have not yet been developed for extracting these elements from low-grade domestic resources in Oregon and California.[25] A new roast-leach method, developed by the Bureau on a laboratory scale, shows promise that these metals may be extracted competitively. The fiscal year 1976 research will complete the laboratory investigations, and permit the construction of a small continuous process extraction unit.

The United States must import more than 50 percent of its *gold* and *silver* supplies. Several novel, low-cost methods that have been developed by the Bureau in recent years for recovering gold from low-grade refractory ores have been adopted by industry. Laboratory studies, followed by field testing in cooperation with industry, are applying these technologies to the recovery of gold and silver from mining and milling wastes and from low-grade deposits heretofore considered subeconomic.

The United States is largely self-sufficient in *copper*, but the higher-grade deposits are being depleted rapidly. Therefore, mining and treating of progressively lower-grade, deeply buried, and otherwide submarginal deposits must be accomplished—including the treatment of mining and milling wastes—in order to meet the increasing domestic demand. Several novel methods are being investigated, including in-situ leaching and advanced heap-leaching. In addition, testing of an innovative Bureau-developed electric-furnace smelting technique is being undertaken, and efforts are being made to develop economic processes for recovering the nickel and copper from complex Minnesota ores near Duluth.

More than 95 percent of the rutile (*titanium dioxide*) that is used in the United States must be imported. Although rutile is scarce in the United States, ilmenite [26] is abundant; therefore, the Bureau's research has focused on recovering its titanium. Several promising processes have been developed on a laboratory scale, but additional research is needed before they can be tested on a larger scale.

Research on iron and steelmaking will focus on the concentration of nonmagnetic taconites. Such Bureau research to date has resulted in the construction of a new plant at Tilden, Mich.—which increased U.S. production capability of iron ore by 5 percent. Other deposits of nonmagnetic taconite will be investigated, as will the recovery of super-

[23] Bauxite—an impure hydrated aluminum oxide, the principal ore of aluminum; usually with the impurities silica, clay, silt, and iron hydroxides.
[24] Aluminum oxide, an intermediate product formed in the processing of bauxite for aluminum.
[25] Estimated to contain enough nickel and cobalt to satisfy U.S. needs for 25 years.
[26] A mineral containing iron, titanium, and oxygen—the principal ore of titanium.

grade iron product from taconite, which are then suitable for direct smelting to make steel. A major program last year was to determine the feasibility of using solid fuels (lignite and sub-bituminous coal) as a replacement for oil or natural gas in the high-temperature fire-hardening of iron-ore pellets.

Air-pollution controls have placed increased pressure on the *lead-zinc* industry to modify its processing methods so as to eliminate sulfurous stack emissions (see next section). The Bureau's minerals-technology research is concerned mainly with developing new methods of recovery of lead and zinc, which will circumvent this problem.

Florida produces more than 80 percent of U.S. *phosphate-rock* production and, with the expected increased domestic demand, reserves of these high-grade phosphate deposits are expected to last for about 15 years. The Bureau is continuing its research to improve phosphate recovery from these deposits, and will study the beneficiation of low-grade phosphate deposits that are presently subeconomic—such as Florda's Hawthorne Formation, of deposits in North Carolina and Tennessee, and the calcareous phosphate-rock deposits in the Western States.

Desulfurization of stack gas

This program requires an increase to $5.3 million in fiscal year 1976 to complete construction of a pilot plant. The citrate-process technology program of the Bureau, for scrubbing the sulfur oxides from stack gases of powerplants that burn high-sulfur coal, received a boost in fiscal year 1975 when the Bureau was given funds to design and construct a pilot plant [27] in order to confirm the engineering reliability and to refine the cost estimates. The Environmental Protection Agency, which cooperated in the program during fiscal year 1975, is expected to continue its cooperative agreement this year; the project will be a joint cost-sharing effort with industry, and negotiations were underway in the spring of 1975 with several industrial firms.

The citrate process was originally developed to remove sulfur dioxide and recover the sulfur from nonferrous smelter gases, and it is currently being tested at the lead smelter of the Bunker Hill Co., near Kellogg, Idaho. This project will allow transfer of the technology, developed by the Bureau, to the electric power generation industry in order to permit it to meet air-pollution regulations when burning high-sulfur fuels.

The citrate process also offers the advantage of producing elemental sulfur, instead of the sludges that result from scrubbing processes and which must be placed in impoundments and disposed of.

To compensate for the high priority assigned to the pilot plant project, the Bureau's laboratory research had to be decreased in fiscal year 1976, thus curtailing projects dealing with:

—solid and liquid absorbents for sulfur and nitrogen oxides;
—chemical methods for removing sulfur from coal; and
—development of knowledge on the fate of toxic elements in combustion systems.

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[27] During fiscal year 1976 the construction contracts will begin on a pilot plant designed to treat flue gas from a steam-generating plant of approximately 75 MW capacity, burning coal with about 3 percent sulfur. Successful completion of this large-scale pilot plant operation will lead to the opportunity for scale-up to full-size commercial units that can process more than 200,000 cubic feet per minute of gas.

Pollution abatement

The wise desire of the public to achieve improved environmental quality has placed severe constraints on the processing of mineral resources. In many cases, control methods do not exist; in others, compliance with pollution-control regulations can be achieved only through the use of high-cost control devices or the curtailment of production. It is therefore essential, if the United States is to maintain or expand its mineral production to meet domestic needs, to develop economic methods that will minimize the pollution that is caused by the domestic minerals-processing industry. In fiscal year 1976 the Bureau has earmarked $2.4 million for this effort.

Over the years the Bureau has made considerable progress in *air-pollution* abatement, one of the more recent accomplishments being the aforementioned citrate process for removing sulfur dioxide from flue gases. The Kellogg, Idaho test of the continuous-process development unit will be in the third and final year of its original test program in fiscal year 1976.

Because the Nation's water resources are becoming increasingly precious, it is essential that technology be developed for reducing *water pollution* and encouraging the recovery and reuse of water. The availability of water for mineral-processing activities is especially critical in the arid and semiarid regions of the United States, where many major metallurgical processing plants are located. Bureau research focuses on identifying the water contaminants,[28] and developing techniques for their chemical neutralization or removal.

Several potentially useful techniques for purifying waste waters have been developed by the Bureau, including such pollutants as selenium, calcium sulfate, and mineral-flotation reagents. Field testing of these techniques is being carried out in fiscal year 1976.

Mineral-waste solids already cover nearly 7,000 square miles of the United States and are being generated at the astounding rate of 1.7 billion tons per year. These piles, in addition to being unsightly, are sources of air and water pollution. Some 80 mineral industries generate such wastes, with the copper industry contributing the largest tonnage—followed by iron and steel, bituminous coal, phosphate rock, lead, zinc, aluminum, and anthracite industries.

The Bureau has made significant progress in developing chemical and vegetative stabilization techniques for some of these wastes, and in fiscal year 1976 will pay particular attention to waste piles where vegetative growth is inhibited by soil conditions. In performing this work, the Bureau also provides technical assistance to other Federal agencies and industry.

Some mineral-processing stages, such as the beneficiation of Florida phosphate, generate huge quantities of *slimes*. Technology to dewater these slimes is being pursued by the Bureau, as it will result in land reclamation and the ability to reuse large quantities of water and at the same time eliminate stream pollution that is caused by occasional dam failures.

Secondary resource recovery

In fiscal year 1976, the Bureau plans to spend $2.1 million to develop methods of recovering and recycling the valuable mineral

[28] In some cases these contaminants are potentially valuable—such as waste solutions in pickling and plating plants—and their recovery could help offset the cost of purifying the waste solutions.

constituents in wastes, and to improve the recovery efficiency and the quality of the secondary resources that are presently being recycled. In addition to reducing U.S. demand for primary raw materials, this would reduce the amount of energy required to produce finished metals.[29]

A large part of the Bureau's program deals with *urban refuse.* Research to separate and recycle the various components of refuse that is incinerated is nearing fruition in the design or construction of three plants in Maryland and New York.

The Bureau has also developed a simple method for separating the mineral and energy values from unburned urban refuse, being tested in a 5-ton-per-hour continuous-process development unit; significant features have already been incorporated in a number of proposed commercial plants. Demonstration of the 5-ton-per-hour unit to local governments and industry, testing of modifications to the process, and production of materials for testing by the Bureau and industry, will occupy much of this effort in fiscal year 1976. The Bureau is placing special emphasis on perfecting methods to upgrade and refine the mixed metals thus recovered, in order to increase their commercial acceptability.

Recovery of metals from *industrial wastes* is continuing with the Bureau field testing its two methods for reclaiming aluminum from aluminum dross, in cooperation with industry. Recovery of metallic and nonmetallic minerals from many other industrial wastes still needs to be investigated, as follows:

—Recovery of aluminum, carbon, and fluorine for the "black muds" generated during the production of aluminum; and
—Reclaiming the waste zircon from superalloy casting molds, gallium and germanium from fly ash, and chromium from leather-tanning wastes.

The Bureau has successfully conducted research to encourage the recycling of *junked autos,* and to improve the recovery of some nonferrous metals and plastics from the 9 million autos that are junked each year. However, the composition of junked cars is changing, because magnesium, aluminum, and plastics are being substituted for steel in an effort to decrease automobile weight and improve performance. The Bureau is continuing to transfer its technology to industry through cooperative projects with scrap processors and major auto manufacturers.

Minimizing mineral and metal needs

Materials with improved performance, having the capability to withstand environments that are increasingly hostile to their efficient performance, are needed for construction and fabrication of equipment for chemical and metallurgical processing, in order to reduce the increasing demand for minerals.

Bureau research has indicated that the strength of iron can be increased greatly by the addition of refractory oxides. In addition, coating methods to protect surfaces of dispersion-strengthened alloys are being investigated, joining techniques for use in manu-

[29] For example, the iron that is discarded in urban refuse, alone, is equal to about 10 percent of U.S. production—and only 25 percent as much energy is required to produce iron and steel from scrap as compared with steel from iron ore.

facturing are being developed, and iron alloys are being strengthened by incorporating fibers of molybdenum into the matrix.

In fiscal year 1976 the Bureau plans to spend $2.9 million (nearly 20 percent more than last year) to conserve our limited supply of raw materials by developing higher quality and improved materials that will have longer life and will perform satisfactorily in more hostile environments. Included in this research activity increase is the development of high-performance steels, and ductile [30] wrought iron. Research to improve the mechanical properties of low-cost metals used in construction (such as magnesium and lead) is being continued.

Manganese-copper alloys for mining tools, which damp vibrations and noise, have been developed by the Bureau and such research is being expanded to include other materials and alloys.

The development of tough, wear-resistant materials is being investigated, with the development of improved cermets, castable carbides, vapor-deposited hard-facing compounds, and electrodeposited titanium diboride coatings. These advanced materials are necessary for wear-resistant tools and dies, valves, bearing surfaces, and inserts for the surfaces of equipment that receives much wear. Related research is focusing on the development of improved ceramic materials that have good shock resistance and good flexural strength.

The use of titanium in small castings, which has excellent corrosion and strength, is inhibited by its high cost. Bureau research is addressing the production of cheap titanium of less-than-aircraft quality, and the development of cheaper casting and fabrication procedures.

Molybdenum, which has unusual strength at elevated temperatures and is in abundant supply domestically, is subject to catastrophic oxidation. Research is focusing on the development of compatible coatings and composites, and on the production of cheaper molybdenum castings.

Corrosion exacts a huge toll in the United States, estimated to be $20 billion annually. As a basic understanding of the mechanism of corrosion is essential, research is being continued to improve corrosion resistance and alloying techniques.

Alumina pilot plant

The Bureau expects to spend $2 million on the design of several large pilot plants, which can produce 50 tons of alumina per day. Based on the best design, the Bureau plans to request funds to construct a 50-ton-per-day plant. This will be a continuation of the Bureau's effort over the past several years, to develop continuous alumina miniplants using the most promising technologies for the recovery of alumina from low-grade aluminum ores; this has been a cost-sharing cooperative program with industry, in which 10 companies have joined with the Bureau.

The information derived from this single 50-ton plant should permit the scale-up by industry to 1,000–2,000 tons per day commercial-size alumina plants—which will thereby demonstrate that the United States has the ability to meet its aluminum needs from domestic low-grade resources.

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[30] Ductile: capable of considerable deformation, especially stretching without breaking such as being drawn through the opening of a die with a consequent reduction in cross-sectional area.

Uranium-ore processing

Projections by the Energy Research and Development Administration indicate that the domestic production of uranium will fall short of meeting U.S. demand by 1979, so the development of lower-grade resources will be needed to augment domestic reserves—as dependence on foreign sources is undesirable. New and better metallurgical processing will be required, to improve the recovery of uranium from low-grade ores.

Accordingly, the Bureau will spend $1.1 million to investigate the use of novel hydrometallurgical methods in processing refractory and low-grade domestic uranium ores as well as uranium-bearing shales. Working cooperatively with the mining research program, this metallurgy effort will evaluate in-situ processing of low-grade uranium ores.

Geothermal research

Estimates of potential geothermal energy resources in the United States vary considerably, depending on advancements in technology and discovery of resources. Until a number of urgent technological problems are solved, the significance of geothermal energy as a relatively pollution-free source of energy cannot be fully assessed. Accordingly, the Bureau plans to spend $0.5 million on:

—development of new and improved corrosion-resistant materials;
—prevention of scaling; and
—development of technology for recovering byproduct minerals from geothermal brines, and for their safe disposal.

The extremely corrosive nature of the high-temperature, high-pressure saline brines is truly difficult to comprehend, and the Bureau's research is attempting to develop materials having the superior performance needed.

An integral part of the geothermal investigations must, of course, include field tests wherein selected materials are subjected to the wide range of conditions present at several operational geothermal wells—mainly in California's Imperial Valley.

Environmentally-acceptable disposal techniques for brine constituents that are presently nonuseable are being sought, as part of an integrated recovery-disposal system, and the use of partly-depleted brines as process water in metallurgical and chemical operations will also be investigated.

Energy-use patterns

The Bureau's study of energy-use patterns in metallurgical processing began in fiscal year 1974, with supplemental appropriation funds. It is geared to:

—provide information on the amount and kind of energy used in each step of metallurgical processes;
—identify process areas where the type of energy can be changed and improvement can be made in the process; and
—determine areas where innovative changes in technology might bring about significant savings in energy.

A contract was negotiated with the Battelle Columbus Laboratory, whereby the latter will prepare energy flowsheets for processing the primary products of 83 mineral commodities. Reports issued in fiscal year 1976 will analyze the results, and will make recommendations

on energy-conserving practices in metallic and nonmetallic mineral-processing application and will identify research needs.

D. DATA COLLECTION AND ANALYSIS

Minerals information

The Bureau of Mines program of Data Collection and Analysis attempts to produce a coordinated body of minerals information that is basic to the planning, policy, and decisionmaking of the Federal Government and industry. Much of this information is collected and digested by canvass of industry, through more than 200 annual statistical surveys that cover more than 100 mineral commodities. After collection, the raw data are checked for accuracy and processed into a number of statistical series,[31] which cover all aspects of U.S. mineral production, processing, and use. In fiscal year 1974, more than 79,000 establishments were thus canvassed.

In addition, foreign development activities and production data are obtained from various publications, from Foreign-Service dispatches, from other Federal agencies, and from U.S. mineral attachés at foreign posts.

TABLE 5.—DATA COLLECTION AND ANALYSIS ACTIVITIES BUDGETED BY THE BUREAU OF MINES FOR FISCAL YEAR 1976

[Dollar amounts in millions]

	Fiscal Year 1976 estimates	
	Amount	Percent
1. Minerals information	$12.0	82
2. State liaison	2.26	16
3. Mineral—position analysis	.27	2
Total	14.5	100

In fiscal year 1976 the Bureau plans to spend $12 million on minerals information (table 5), which is 20 percent more than last year, increasing the quantity and quality of data acquired by enlarging the research staff (including increased support for foreign language-translation capability).[32]

These researchers will:

—Continue to assess world supply/demand relationships;
—Continue to provide greater detail on U.S. consumption, trade, and dependence on foreign sources of raw materials; and
—Continue to prepare quantitative international trade data on mineral commodities.

This data-collection effort will include increased visits to mines, mills, smelters, refineries, and other plants.

The minerals availability system (MAS) a computerized rapid-response system producing current and refined information,[33] will play an important role in the Minerals Information effort, by providing funding and monitoring for contracts with colleges and uni-

[31] Mineral Industry Surveys, Mineral Trade Notes, International Coal Trade, Commodity Data Summaries, Minerals Yearbook, and the International Petroleum Annual—all of which provide input to the Secretary's Annual Report on Mining and Minerals Policy.
[32] Increased Bureau activity in this program element in fiscal year 1975 resulted from the OPEC oil boycott and the fear of possible OPEC-like actions for minerals.
[33] See discussion in following section herein.

versities that have special expertise or particular access to mineral data.

A second major component of the Bureau's Minerals Information program element consists of commodity analyses, wherein broad resource-management problems and other commodity problems, both within and outside the Federal Government, are examined. This effort includes analyses of the industry and forecasts of supply and demand. Two types of publications are prepared, to disseminate the results of this analytical work:

—Periodic information: These publications include (1) weekly, monthly, quarterly, and annlal *Mineral Industry Surveys;* (2) *Minerals and Materials: a Monthly Survey;* (3) monthly *International Coal Trade;* (4) monthly *Mineral Trade Notes;* (5) *International Petroleum Annual;* (6) annual *Commodity Data Summaries;* (7) annual *Minerals Yearbook*—three volumes; volumes; (8) annual *Status of the Minerals Industries* (and material for the Secretary's *Annual Report under the Mining and Minerals Policy Act);* and (9) every 5 years, *Mineral Facts and Problems.*[34] (See appendix III.)

—Nonperiodic information: these publications include Information Circulars, Reports of Investigations, and Special Publications. Information Circulars are in-depth reports on activities and developments in the mineral industries; Reports of Investigations usually cover narrow aspects of mineral production or technical problems; and Special Publications are popular-type pamphlets prepared for the general public and distributed in response to requests.

A third segments of the Bureau's Minerals Information program is the direct consultation with those who need expert opinion and reliable information, whereby accurate commodity forecasts and the capacity to identify critical deficiencies or price movements in minerals can result.

State liaison

The Bureau has liaison officers serving all 50 States (see Appendix IV), who provide both mineral information and a service function. They maintain close coverage of industry developments, and facilitate cooperation with Federal, State, and local governments, with industry, and with educational institutions.

Mineral position analysis

The Bureau's Mineral Position Analysis has become one of its most significant efforts since 1970, as a result of the Mining and Minerals Policy Act of 1970,[35] which requires the Secretary of the Interior to file an annual report on the status of the mineral industries, with recommendations. A recent Bureau reorganization has expanded and accelerated this effort through the establishment of the Office of Assistant Director for Interindustry and Economic Analysis. The

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[34] Mineral Facts and Problems is developed from an annual internal working series called the Commodity Statements. The Commodity Statements have a major use in the planning of Bureau research activities, and are used informally outside the Bureau. Separate chapters of the 1975 edition of *Mineral Facts and Problems* are being issued, beginning in early October, and all chapters are expected to be available by August 1976.

[35] Public Law 91-631.

work flow for the data collection and analysis program is shown in Appendix V.

The Bureau's Minerals Availability System (MAS) has been designed to deliver a decision-oriented product that relates future U.S. mineral supplies to varying conditions. Input to MAS includes:

—engineering and cost evaluations of individual mineral deposits from the standpoint of their extraction technology and supply availability; and

—display of production-tonnage potential, by existing and potential operating grades assessed over a scale of probability.

Although the use of probability assessment based on decision-analysis theory enhances the evaluation capability for estimating the potential long-term availability of minerals and for determining the extraction-research requirements, the Bureau's program until 1974 was limited to input on domestic deposits of selected critical mineral commodities. Thus a major expansion of input, to include foreign deposits and additional important mineral commodities, is of high priority.

The minerals availability system (MAS) is being implemented in five phases, as follows:

1. Identification and evaluation of mineral deposits;
2. Commodity-supply analysis;
3. Maintenance and refinement of the system;
4. Commodity-supply modeling; and
5. Development of interactive supply systems.

Several dozen commodities are in various stages of completion under Phase 1. Phase 2, which covers the 18 commodities classified as "critical" by the Council on International Economic Policy, is already under way with analysis of copper and aluminum. A prototype copper model (Phase 4) is being developed at the University of Pennsylvania, and Phase 5 includes data and systems other than the MAS supply analysis and models (Phases 2 and 4). All data and systems are being supported by computer.

The MAS system also is making special inquiries into subjects affecting mineral development and production, such as—

—Energy and water consumption;

—Mineral landownership regulation; and

—Reclamation, technologic trends, mineral-transportation modes, and economic factors affecting mineral development and production.

The Fuels Availability System (FAS), providing data in computer mode for analytical and informational purposes, has the following objectives for fiscal year 1976:

—Expand the data base on mines, respondents, consumption, fuel quality, ownership, imports, and foreign fuels;

—Collect and verify new data on price information, transportation, pipeline movements, site location, anthracite, and oil shale; and

—Initiate compatibility discussions and decisions with other agencies such as the Federal Energy Administration, the Federal Power Commission, and the Mining Enforcement and Safety Administration.

A number of new types of reports will be prepared, including:

—The "Materials Surveys" series will be updated; and

—A set of option documents will be developed for certain commodities, addressing specific issues of concern to decision-makers and setting forth possible alternate scenarios and recommended remedial measures.

In order to provide these new products, the function of the Bureau's commodity specialists will require significant strengthening. These specialists will not only have to verify the data bank input and analyze its output, but also they will have to make certain that their analyses are responsive to the most compelling mineral policy needs. In addition, the Commodity Divisions of the Bureau and its Office of Economic Analysis will be required to select and monitor the contracts and grants which broaden the Bureau's capabilities.

E. ENGINEERING, EVALUATION, AND DEMONSTRATION

The Bureau's program element for Engineering, Evaluation, and Demonstration received $12.9 million in fiscal year 1976, an increase of $2.9 million over last year. In this program the Bureau's objectives are to help insure the environmental quality of areas that necessarily must experience greater development and use of their natural resources, as provided for under the National Environmental Policy Act of 1969 (NEPA).

Not only will current mining activities be studied, but also the resolution of environmental problems connected with mining in the past—such as mine subsidence, disturbance of surface-mined land, fires both underground and in coal outcrops, waste banks, and mine-water control.

In addition, the Wilderness Act of 1965 gave responsibility to the U.S. Bureau of Mines and the U.S. Geological Survey for making mineral surveys of areas that were taken directly into the National Wilderness Preservation System, as well as those that are being considered for such designation. Other mineral studies are conducted by the Bureau on National Game and Wildlife Refuges, and other Federal land areas (such as Wild and Scenic Rivers) that are proposed for withdrawal from mineral entry.

In performing its engineering, evaluation, and demonstration studies, the Bureau carries out projects that have been specifically authorized by the Congress, under:

—The Mine Fire Control Act, Public Law 83–738;[38]

—The Mine Drainage Control Act, Public Law 84–162;[37]

—An amendment to Public Law 84–162 (Public Law 87–818), which provides for public health and safety mine-sealing projects;[38] and

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[36] 68 Stat. L. 1009.
[37] 69 Stat. L. 352.
[38] 76 Stat. L. 934.

—The Appalachian Regional Development Act (Public Law 89–4, sec. 205), as amended by Public Law 91–123, Public Law 92–65,[39] and Public Law 94–188.

In fiscal year 1976 the funds for this program effort will be distributed as shown in Table 6. A major increase of 1.5 million in Wilderness Program activities and on Alaskan lands is accompanied by increases for Mined Land Investigations in the Pennsylvania anthracite area and the Rock Springs, Wyo., mine void-filling project.

TABLE 6.—ENGINEERING, EVALUATION, AND DEMONSTRATION ACTIVITIES BUDGETED BY THE BUREAU OF MINES, FISCAL YEAR 1976

[Dollar amounts in millions]

	Fiscal year—		
		1976 estimates	
	1975 actual	Amount	Percent
1. Anthracite area mined-land investigations and demonstrations	$5.35	$5.8	45.0
2. Wilderness	1.35	2.8	22.0
3. Engineering and environmental investigations	2.4	2.25	17.5
4. River basin studies	.3	.3	2.5
5. Fire control in coal deposits	.24	.24	2.0
6. Subsidence, Rock Springs (Wyoming)	.5	1.5	
Total	10.1	12.9	99.0

Anthracite area mined land investigations and demonstrations

Research and demonstration activities will continue both in the laboratory and in the field on this program element, which has the dual objectives of:

—solving problems resulting from past mining; and

—preventing similar problems in current and future mining.

Special attention will be given to developing better control of surface subsidence, using the pumped-slurry process[40] in which coarse anthracite waste materials will be used under a wide variety of conditions. Because the cost of crushing material to fine sizes constitutes a major expense in any such backfilling project, special attention will be given to the use of coarse materials and their simultaneous injection into multiple mine voids.

New techniques for extinguishing burning anthracite mine-refuse banks will be investigated. (Figs. 22–23.) Ways of using or removing the nonburning banks will also be looked into, as they are esthetically displeasing, sources of acid water, and potential sources of air pollution if ignited.

[39] 79 Stat. L. 5 sec. 205 of Public Law 89–4, as amended, requires the Bureau to continue the engineering, management, and administration of mined-area restoration projects that are approved by the Appalachian Regional Commission. The Commission supplied funding to the Bureau for projects of various kinds, including:

Control of underground mine fires;
Prevention of mine subsidence;
Reclamation of publicly owned surface-mined lands;
Removal of nonburning coal waste banks, and the extinguishing of burning ones;
Sealing of abandoned oil and gas wells; and
Covering of mine openings, to control mine-drainage pollution.

Such projects are generally funded by 75 percent Federal and 25 percent State dollars, except for projects on Federal lands—where the Federal Government pays the complete bill.

[40] Wherein materials are injected hydraulically, under pressure, through a limited number of boreholes into inundated and otherwise inaccessible mine openings.

FIGURE 22.—Mine waste bank, afire.

FIGURE 23.—Same mine waste bank, fire extinguished and land reclaimed.

Techniques for preventing the outbreak of underground mine and outcrop anthracite fires will be investigated, including the development and use of materials that could provide effective seals against ignition from natural causes. Also, the sealing of strip-mine pits to prevent the generation of acid water will be investigated.

The creation of recreational areas from strip-mined anthracite land will be studied further, as will the feasibility of applying very large-scale surface mining and reclamation technology to available deposits of strippable anthracite.

Infrared and other airborne thermal scanning for mine fires, for burning mine-waste banks, and for abandoned surface-mined lands will be extended—which will show water-level buildups and recessions. Under the Mine Drainage Control Act, a comprehensive network of permanent mine-water pool-monitoring stations throughout the anthracite region will be instituted, in cooperation with the Commonwealth of Pennsylvania—which plans to initiate a program under the Amended Act to seal and fill several dangerous abandoned mine shafts.

The very valuable Anthracite Mine Map Repository, including data on current and past operations, will be microfilmed and the systematic indexing and data-retrieval systems will be expanded.

Investigations will also be made of the most appropriate ways in which Pennsylvania anthracite can contribute to alleviating the Nation's energy shortage, with the identification of impediments to increased anthracite production along with appropriate investigation of cost recovery from mine waste and the possible use of mechanization for underground extraction of coal from steeply dipping (steep-pitch) seams.

Wilderness

Wilderness mineral studies will be continued in areas to be taken directly into the national wilderness preservation system, in primitive areas being reviewed, and in other Forest Service lands being considered for inclusion. The program covers 441 forest areas, having almost 31 million acres, in 33 States. Provisions are before the Congress which would extend the Wilderness System into the acquired forest lands of the Eastern United States, amounting to perhaps 59 areas that contain 625,000 acres.

Mineral studies are also scheduled to begin, on the recommendation of the Secretary of the Interior, in five National Game and Wildlife Refuge Ranges (Arizona, Montana, and Nevada), and in the Glacier Bay National Monument (Alaska). Altogether these ranges cover 7.8 million acres.

Of the total lands scheduled for mineral studies—447 areas with 38.7 million acres—through fiscal year 1975 such investigations had been completed for 15.4 million acres (40 percent); the remaining 318 areas are scheduled for completion by 1982. Specific study areas are selected in conjunction with the U.S. Geological Survey from lists of priorities that were developed by the U.S. Forest Service. The Bureau plans to investigate 2 million acres in fiscal year 1976.

Engineering and environmental investigations

Field offices of the Bureau conduct engineering and technological investigations of the availability of resources and their production problems. These cover technical, economic, social, and environmental

factors that are associated with specific systems of mining, metallurgy, ceramics, energy generation, and recycling. Cooperative services are also provided to industry, and to State and local governments.

The Bureau's effort in this program area will consume in fiscal year 1976 an estimated $2.5 million, essentially the same as last year, and the same sort of studies will be carried out.

The Bureau will provide advice and comment on environmental problems related to the mineral and fossil fuel industries, through interagency committees, and land-use planning groups at Federal, State, and local levels, as directed by NEPA. The Bureau will make reviews of environmental impact statements that cover such areas as:

—air-quality implications of energy development;
—mining and mineral land decisions;
—solid-waste and recycling enterprises; and
—resource conflicts.

Current costs of selected surface coal mining operations for mined land reclamation will be compiled and substantiated—both through industry contacts and field observations.

Under the parallel State Cooperative Program (see section III, D, herein), the field offices will conduct field and laboratory examinations, economic studies, resource appraisals, and other mineral studies of mutual interest.

Mineral studies of certain Alaskan Native Land Claims will be made, in cooperation with other Federal agencies and the State of Alaska, to aid in the selection and disposition of land. In addition, technologic and economic studies of problems related to the development of Alaskan mineral deposits will continue, including the identification and monitoring of oil seeps.

River basin studies

The Bureau's contribution to the River Basin program, which is aimed to develop the water and related land resources of the Nation, will consist of:

—mineral and mineral economic studies of sub-basins;
—the same for Indian reservations;
—studies of water flooding of oil fields and gas fields (including the completion of those already underway for North Dakota); and
—the same for coal resources by States, separated according to strip-mining and underground methods.

Regarding coal and lignite resources, studies will be directed toward the availability of coal lands for surface mining; the commitment of coal reserves to thermal power, the production of synthetic fuels and coal chemicals, alternative modes of coal transportation, and environmental impacts of coal mining and processing and of ways to alleviate those impacts. The matter of competing land uses will be addressed specifically.

Updating the Mineral Atlas and the accompanying mineral resource report Northern Great Plains Resource Program) will be done, relative to coal development in the Powder River and Fort Union coals of Montana, Wyoming, the two Dakotas, and Nebraska. The Bureau will also continue its participation in the management team on water for energy, to develop option papers for top-level management

decisions regarding the allocation of water to energy-development sites.

Mineral examinations are also made by the Bureau of numerous reservoir sites, to determine if the proposed construction would have adverse effects on mineral resources. The Bureau reviews final reports of the Corps of Engineers, the Soil Conservation Service, and the Federal Power Commission, and memorandum reports are submitted to the Interior Secretary's office; similar reviews are made of Bureau of Reclamation final reports, and Bureau of Mines reports are submitted directly to the Bureau of Reclamation.

Fire control in coal deposits

The Bureau will spend $240,000 in fiscal year 1976, as part of its continuing responsibility under the Mine Fire Control Act of 1954 (Public Law 83–738), whereby it administers projects to extinguish underground fires and coal-outcrop fires on public lands, Indian lands, and on private property.[41]

F. PROGRAM ADMINISTRATION

Program administration costs of $1.15 million for fiscal year 1976 (a 3-percent increase over last year) will be enlarged by $108,000 for additional maintenance and upgrading of the Bureau's research facilities at Pittsburgh and Bruceton, Pa. The budgeted administrative costs of the Bureau amount to about 1 percent of its estimated appropriation for fiscal year 1976.

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[41] Private-property costs are paid on a 50–50 basis, whereas all others are completely paid by the Bureau of Mines.

IV. Recent Accomplishments of the Bureau of Mines

A. GENERAL STATEMENT

Some of the more recent accomplishments of the Bureau of Mines have been mentioned in a preceding section dealing with the last 20 years of the Bureau's operations. This section will discuss only those that were described in the Bureau's budget justification for fiscal year 1976.[1]

B. MINING RESEARCH

In the area of *Coal Mine Health and Safety Research*, Bureau tests have shown that deeper cuts in coal and reduced bit speed will result in lower energy consumption and in reduced dust levels. The use of high-expansion foam for suppression of respirable dust, which was evaluated in five mines on five different types of mining machines, showed the foam to be only slightly better than conventional water sprays, however. A portable battery-operated respirable dust-recording mass monitor was developed and tested successfully.

Extensive testing of a discriminating earmuff (previously developed by the Bureau) on human subjects in the laboratory verified that this equipment can protect the wearer against noise, while at the same time permitting him to hear speech and low-level warning signals.

A field survey of airborne toxic constitutents associated with surface coal-mining operations was conducted, and a handbook describing the sampling methodology was prepared as a guide for MESA inspectors.

Field demonstrations have shown that the technology is now available to degasify the Pittsburgh (bituminous) coal bed in advance of mining, thus reducing the ventilation requirements; more efficient use of equipment such as continuous miners is facilitated, providing both safety and economic benefits. Also, the high-quality gas thus recovered is of commercial value, providing a further economic incentive.

Hydraulic fracturing—a technique that is widely used in the oil and gas industry—was successfully demonstrated[2] in stimulating the production of gas from coal beds, resulting in the formation of enlarged vertical fractures without harm to the rock strata above and below the coal bed. A 1,730-foot hole drilled from the surface was successfully diverted from the vertical so as to penetrate along the coal bed for 413 feet; this produces a larger gas-collection area for degasification, and could be an alternative to drilling a number of vertical holes.

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[1] "Bureau of Mines," pp. 607–711 in "Department of the Interior and Related Agencies Appropriations Fiscal Year 1976": *Senate Hearings, Committee on Appropriations, 94th Cong., 1st sess., pt. 1*, Justifications (especially pp. 636–9, 657–68, 673–5, and 682–4).

[2] A vertical degasification hole in the Mary Lee coal bed, after hydraulic fracturing, produced an average of 50,000 ft³ of methane per day for 1 year; during the 2 years before hydrofracture treatment, the same well had produced only 4,000 ft³ per day.

An inexpensive, yet accurate and reliable, continuously recording unattended methanometer was developed. A study of air-water permeability of the Pittsburgh and Pocahontas bituminous coalbeds delineated the relationships between water saturation, rock pressure, permeability, and methane flow.

The effectiveness of the plugging technique for sealing abandoned oil and gas wells that penetrate coal beds was further documented, as four more wells in four States were plugged and then the effectiveness of the seals was monitored.

Two prototype passive water barriers were developed, which are effective against dust explosions.

Progress toward reduction of roof-bolting injuries was achieved by the development of (1) a bolt bender-inserter and (2) remote drilling techniques. Five parallel contracts were let, to test five different prototype remote-drilling systems that have met drilling requirements in laboratory tests.

A study was completed on the state-of-the-art on protective canopies, and the maximum size of entry required for safe operation of electric face-equipment having canopies.

A controlled roof-fall experiment, which tested a wide variety of predictive techniques, demonstrated that the microseismic technique offers the greatest potential.

A concept of illuminating a long-wall face area was developed, and a fluorescent prototype was fabricated and installed in two operating long-wall mines for evaluation. Second generation models of each of three types of machine-mounted lights (fluorescent, mercury vapor, and high pressure sodium vapor) were developed; they are smaller, more simple, and more reliable than previous models.

Underground tests showed that with UHF radio (420–460 MHz), reliable voice communications can be maintained between a portable unit in the mining section and the surface of the mine, by using a transceiver located approximately in the center of the section. A "Call Alert" system was developed, which consists of small pocket-size receivers worn by roving miners; it can be selectively activated from the surface or from other remote locations.

A miniaturized mine-monitoring and telemetry system has been developed, which monitors four parameters (methane, ventilation, carbon monoxide, and temperature) and computes the rate of temperature rise.

Two prototypes of self-contained emergency-breathing apparatus, developed by the Bureau, have been tested and approved by NIOSH (National Institute of Occupational Safety and Health) for use in underground mines, one having a 10-minute and the other a 1-hour supply of oxygen. Each unit will protect the miner regardless of the toxic gases in the mine air. The 10-minute apparatus can be worn on the miner's belt and the 1-hour apparatus can be stored nearby for emergency use.

Two improved communications systems for rescue teams have been developed by the Bureau—one a versatile lightweight walkie-talkie radio, and the other a hands-free, bone-conduction microphone and ear speaker mounted on the rescue member's hardhat with a relatively lightweight wire connecting the fresh air base and rescue team units. An infrared viewer was evaluated at the Bureau's experimental mine at Bruceton (Pa.); clear images of men were obtained

over a distance 250 feet through dense coal smoke. The surface seismic system, developed previously for detecting signals generated by trapped miners, was modified for underground application; underground tests showed that miners could be detected at distances greater than 1,000 feet.

The Bureau's technology-transfer program continued to play an active role, through panel discussions at meetings and informal contacts with mining industry groups. A new publication, *Technology News*, is being sent to 2,000 individuals in mining and allied industries.

In the area of *Metal and Nonmetal Mine Health and Safety Research*, six comprehensive measurement surveys of respirable dust were conducted, which show that diesel engines can contribute significantly to respirable particulate levels in underground mines.

A dust-control technique for a mill-bagging operation was developed, which reduced the dispersion of respirable dust into the mill by more than 90 percent—although the dust exposure to the bagger as measured by the man-mounted sampler was reduced by only 20 percent.

A 5-channel, continuous radon gas monitor was constructed, and preliminary tests showed that it has good sensitivity for the normal concentrations encountered in uranium mines. Radon barrier coatings were tested at the Bureau's research uranium mine, and reduced radon emanation by 60 percent or more.

A Bureau-designed yielding rock bolt that maintains its anchorage while undergoing several inches of displacement has been demonstrated at Hecla's Lucky Friday Mine in Idaho. The yielding bolt was compared with conventional expansion-shell bolts and with fully grouted resin-anchored bolts, and the yielding bolts and the resin bolts were able to maintain their support capability while undergoing significant rock displacement.

Field work for a microseismic slope-failure detection system is continuing at the Ruth Mine, near Ely (Nev.), with two slides being successfully predicted to date—one was a small slide with no significant hazard or production loss, but the other amounted to more than 200,000 tons of material that stopped production during the cleanup.

Among the various products released during incipient combustion, the submicron particulates show the greatest promise for detection purposes. Because presently available instruments are expensive and not particularly "mine-worthy", a new ionization-attachment detector was designed and is undergoing testing.

A modified version of the electromagnetic system for locating trapped miners in coal mines was tested in several deep metal mines. Signals transmitted through 4,000 feet of rock overlying the mine passageways were detected successfully at the surface.

In the area of *Coal Mining Technology*, the comprehensive 5-year program to improve coal extraction (begun in May, 1974) now constitutes an aggressive effort strongly oriented toward contract research, with emphasis on cooperative cost-sharing with industry. Two of these cost-sharing research contracts have made considerable progress, as follows: (1) An 18-foot diameter tunnel-boring machine has been acquired and modified to meet health and safety regulations, and is now beginning underground trials; it will demonstrate the advantages of a bored single-entry mine development over conventional driven mine entries. (2) A full face of powered European shield-longwall

supports has been proof-tested, and has been installed in a Western coal mine for testing and demonstration.

In addition to these cost-sharing projects, the first two stages of a three-stage, self-advancing, conical-boring device were fabricated and tested successfully. The unit drilled rock at a rate about 50 percent faster, and using only 10 percent of the thrust of conventional boring units.

In the area of *Oil Shale Mining Technology*, initiated in fiscal year 1975, a 5-year comprehensive plan has been developed, along with the implementation of the first stages of a contract-research program.

In the area of *Metal and Nonmetal Mining Technology*, the Bureau has shown that fracturing of ore bodies in preparation for in-situ extraction has a high potential for deposits that are presently uneconomic for mining by conventional methods. In the Bureau's cooperative research program at the Emerald Isle Mine, Arizona, a test blast produced such encouraging results that the company decided to expand the pit-bottom leaching into a commercial-scale operation.

Present mining techniques for underground metallic deposits commonly involve the hoisting and processing of all mined material, in order to recover less than 5 percent of the weight as a valuable product, and after separation the waste is often returned to the mine for underground support. The Bureau developed a technique to separate as much as 50 percent of the waste underground, near the face.

A comprehensive review and analysis of the current large-scale, noncoal mining industry was completed, thus providing a tool for both industry and Government to use in problem definition and priority assessment of research objectives.

The Bureau completed field testing on equipment and techniques to control the flow of water and to stabilize mine-waste dumps with sulfur-based materials.

Electrical resistivity, horizontal-profiling methods to map faults were tested where known faults cannot be detected by conventional aerial photography and are difficult to delineate by conventional surface mapping. Interpretation of the resistivity data showed that fault-like structures can be traced over long distances.

As an alternative to the drill-blast cycle, the Bureau successfully tested (a) thermal-mechanical and (b) thermal-hydraulic methods of primary rock breakage, in the Diamond Point Granite Quarry at Cold Springs, Minn., and in a basalt quarry at Dresser, Wis., with considerable energy savings.

A full scale field test demonstrated that unclassified [3] hydraulic backfill can be electro-kinetically densified effectively and safely, with low power consumption. Industry has shown considerable interest in this Bureau demonstration.

A comprehensive analysis of ore-handling systems in underground metal and nonmetal mines was able to identify inefficient and unsafe operations, and led to recommended improvements. A major problem

[3] Classification—the process of separating particles of various sizes, densities, and shapes by allowing them to settle in a fluid.

was the control of muck [4] size, because over-size ore is a principal cause of high labor costs, low productivity, and high accident rates in many mines. The rock is usually broken manually by double jack and blasting of individual pieces, so an alternative was proposed to develop a self-propelled mechanical rock breaker. Other ore-handling problems are resource utilization, system balancing, chute drawing,[5] car loading, and slushers.[6]

To improve the drill-blast cycle, the Bureau tested the concept of a large-hole burn-cut; [7] this produced pulls of as much as 20 feet with a single blast round.[8]

In the area of *Explosives*, there was renewed interest in their use for stimulation of oil and gas wells and for fracturing of oil shale for in-situ retorting. The Bureau is devising techniques to evaluate the sensitivity and behavior of explosives under pressure and at elevated temperatures. Of 46 different formulations that were surveyed for sensitivity retention under pressure, only four commercial formulations were considered suitable.

In the Bureau's work on hazardous materials and on detonation growth and decay, an underwater test was devised for determining the hazards of materials that are only marginally explosive, and the test was applied to a series of such questionable materials. Because of the favorable results of this test, the technique is being considered by the American Society for Testing Materials.

In addition, the Bureau partly completed an extensive study of the projectile-bullet-and-cap sensitivity of high explosives and blasting agents. Results showed that blasting agents which are insensitive to a No. 8 blasting cap cannot be initiated by conventional rifle ammunition, when unconfined.

C. METALLURGICAL RESEARCH

More than 40 percent of the U.S. iron requirements are supplied from domestic high-grade iron-ore pellets that must be fire hardened for shipment and smelting, using natural gas or oil as fuel. Several years ago, anticipating a shortage in supplies of natural gas and fuel oil, the Bureau began studying the *substitution of low-rank coals*, which has shown that it is feasible—in an 800 pounds-per-hour continuous rotary kiln—to use lignite, bituminous, and subbituminous coals as fuels.

Used brass foundry molding sands, which contain as much as 5 percent brass, formerly were discarded after a single use. The Bureau developed a simple mineral-processing technique that recovers substantially all of the *sand and brass*, for reuse; one foundry has adopted the method, recovering brass worth $60 per ton of molding sand thus treated, and recycling sand worth $19 per ton.

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[4] Muck—rock or ore broken in the process of mining.
[5] Chute drawing (or chute loading)—in metal and nonmetal mines, the loading of ore or rock into mine cars underground by opening and closing chute gates.
[6] Slusher—a scraper loader.
[7] Burn cut—a type of drill-hole pattern for firing a round of shots in a mine heading, in which the holes are drilling parallel to each other and straight into the face, one or more holes being left unloaded for the others to break into.
[8] Blast round—a set of holes drilled into a mine heading, and charged for blasting; usually fired instantaneously, or with short-delay detonators.

A fertilizer material, *potassium sulfate*, has been recovered from Great Salt Lake brine heretofore, incompletely. Bureau research during the past 2 years has developed a simple flotation process that substantially increases the recovery, economically.

Bureau research has led to a way to reduce the cost of manufacture of *thin-walled titanium castings*, and to increase their strength, by using zircon-sand molds instead of the currently used rammed-graphite molds. The castings made from zircon-sand molds are more than six times stronger than similar, plain carbon-steel castings; furthermore, the zircon-sand molds can be processed and reused indefinitely, whereas the graphite can be used only four times on the average.

Bureau engineers and scientists have achieved national recognition in geothermal research dealing with the resolution to the severe *corrosion and scaling* problems associated with the production of energy and recovery of minerals from geothermal brines

Copper blast-furnace slags, which contain as much as 100 pounds of copper per ton, are currently discarded. Bureau research has developed a simple mineral-processing scheme to recover the copper in the slags, and a company plans to install a full-scale plant.

Recovery of lead and zinc from sulfide ores by conventional processes generates noxious *sulfur dioxide*. Bureau research in the laboratory, using a new chlorine leaching-electrolytic scheme, has shown encouraging progress in this regard; in addition, the process is applicable to the recovery of lead and zinc from complex ores—difficult for small mine operators to market—and energy requirements of this process are lower than for conventional processes.

Automobiles in recent years have contained increasing amounts of the *plastic*, polyurethane, in padding and seat cushions and insulation. Recovery of this material would not only ease a serious disposal problem, but also would conserve the valuable petroleum raw materials from which the plastic is made. The Bureau has devised such a polyurethane-recovery process, in cooperation with two major auto companies.

Mineral processing waste waters must be decontaminated, purified, and conserved, in order to abate pollution. Bureau research has resulted in a simple procedure to remove trace quantities of selenium, an extremely toxic element from waste waters in plants that produce zinc; and the process permits reuse of the treated water.

Stainless steel alloys require substantial quantities of *nickel and chromium*, critical materials that must be imported. The Bureau is attempting to utilize a technique known as ion implantation, which shows promise as a means of conserving these metals.

Aluminum has been replacing copper in selected types of heat exchangers (air conditioners, automobile radiators, etc.). However, *field repair of the brazed aluminum* units has been infeasible because of the extremely close temperature control required. The Bureau has devised a technique that permits field repair of the units by using a special flux and solder. Perfection of this technique should make field repair economic, with substantial savings of aluminum.

All coal-gasification processes that upgrade low-Btu gas into high-Btu (pipeline-quality) fuel require a catalytic conversion step. The *catalyst* (Raney nickel) is derived from a brittle aluminum-nickel alloy, which is applied to the reactor surfaces by flame spraying—a

slow and tedious process. The Bureau has designed a process of flame spraying that is 15 times as fast, using an improved feedstock.

A Bureau-developed process for recovering gold, carbon-in-pulp cyanidation, has been successfully applied to the extraction of *silver* from low-grade ores and processing plant wastes. Another Bureau-developed process for recovering *gold* from carbonaceous ores, using a preliminary chlorination step, has been adapted to the operations of a gold ore-mining and processing firm in Nevada. Pilot-plant work at an operating mine at Creede (Colorado) has shown that 70 percent of the silver can be recovered from mill tailings that contain only 3 ounces of silver per ton. The company is now considering the design of a plant that will treat 300 tons of its tailings per day, recovering silver worth almost $1 million per year.

A Bureau method for the production of mischmetal [9] has been adopted by industry. In January 1975 the Rare Earth Metals Co. of America announced that it was beginning the construction of a full-scale 20,000-ampere molten-salt electrolytic cell having an annual production capacity of 250,000 pounds of mischmetal. The Bureau method permits the electrolysis of rare-earth oxides in a fluoride bath, whereas the traditional method uses rare-earth chlorides.

D. DATA COLLECTION AND ANALYSIS

Commodity Data Summaries—1975, a 193-page detailed report that provides salient 1974 statistics and estimates for 1975 on 95 minerals, was published in mid-January 1976—an exceedingly speedy effort for this useful compendium of minerals information.

A special report on 18 *critical imported materials* was published in December 1974 by the Council on International Economic Policy and the National Security Council as a result of the work of its joint task force, for which the Bureau contributed a major part of the background data and information.

An *energy survey* of the U.S. mineral industry, covering some 80 mineral commodities, was completed.

Evaluations were made of (1) domestic lead resources, (2) flow and recovery of copper and zinc scrap by end-use categories, and (3) methods and costs of dust control in stone-crushing operations.

A mathematical model was developed, under contract with the Virginia Polytechnic Institute, to calculate the total *cost for various levels of reclamation of surface coal mines* according to different state laws and standards.

Two publications were issued, which summarized the *mining and petroleum laws* of Europe and Africa—thus completing the 5-volume set that covers all regions of the world.

The Nation's coal reserves were assessed, through the publication of the brief *Demonstrated Coal Reserve Base of the U.S. on January 1, 1974;* two detailed backup documents were also published, documenting the coal reserve base for underground mining in the Eastern and Western United States.[10] In addition, a broad-based study of all

[9] Mischmetal—a natural mixture of rare-earth metals cerium, lanthanum, and didymium; also, the waste matter from a monazite (a phosphate of thorium and the above three rare earths) sand after extraction of thoria (thorium oxide), which may contain large quantities of these rare-earth metals.

[10] Matson, Thomas H. and Doss H. White, Jr., "The Reserve Base for Underground Mining in the Western United States": U.S. Bureau of Mines Information Circular 8678, 1975, 238 p. USBM, "The Reserve Base of Bituminous: Coal and Anthracite for Underground Mining in the Eastern United States": U.S. Bureau of Mines Information Circular 8655, 1974, 428 p.

energy fuels during 1972, showing reserves, production, and consumption, was published.

A new publication series was begun. Entitled "Minerals and Materials; a Monthly Survey," it presents current statistics for major mineral commodities in tables and graphs, and describes highlights of recent events in the minerals industries.

The economic significance of the *Florida phosphate industry* was the subject of a publication,[11] because of the increased concern in Florida for environmental enhancement and the phosphate industry's relationship to it.

A significant study was completed [12] for 21 leading U.S. *coal-producing companies* (which produced 55 percent of the Nation's coal in 1973), giving in-depth financial and corporate-structure analysis. It evaluates the economic health of the coal industry and its capability to generate the capital required to provide the increased coal supply needed to meet emerging demand, by studying the 5-year (1969–1973) performance of each of the 21 companies.

E. ENGINEERING, EVALUATION, AND DEMONSTRATION

In the program of *Mined Land Investigations and Demonstrations*, the following were accomplished:

—Reclamation for future use of a 126-acre tract of mined land in the Lackawanna County, Pa., anthracite region was virtually completed.

—The final phase of a large-scale demonstration project in the Green Ridge area of the Scranton, Pa., anthracite region was completed, involving the injection of more than 1 million tons of coal refuse underground by the pumped-slurry method. This provided support against subsidence for 86 acres and cleared 12 acres of land for future use.

—In the Minooka area of Scranton, an investigation was completed by the Bureau and the Commonwealth of Pennsylvania into the effectiveness of the pumped-slurry injection method for forcing material into old mine workings that lie above the water table [13] and are already partly caved in. This work, which was carried out under 17 acres of heavily built-up land, "seemed to indicate that the new technology could be used to control subsidence under difficult conditions" where other methods have not been effective.[14]

—At Rock Springs, Wyo., the third stage of a long-range project testing the pumped slurry injection process under a wide variety of underground conditions was completed. Sand is being injected into abandoned mine workings underlying 200 acres of the city, where subsidence is expected to occur unless

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[11] Wang, Kung-Lee, B. W. Klein, and A. F. Powell, "Economic Significance of the Phosphate Industry": U.S. Bureau of Mines, I.C. 8653, 1974, 51 p.

[12] Johnson, Robert E. and T. T. Tomimatsu, "The American Coal Industry—Its Structure and Financing"; paper presented before the American Institute of Mining Engineers' Economic Subgroup, New York City, February 17, 1975; also, Tomimatsu, T. T. and Robert E. Johnson, "The State of the U.S. Coal Industry; a Financial Analysis of Selected Coal-Producing Companies, with Observations on Industry Structure"; USBM Information Circular 8707, March 1976, 32 p.

[13] Water table—the level of permanently saturated underground rock and other material; in Pennsylvania it may be near the surface, or in some areas many tens of feet below the surface.

[14] Bureau of Mines, in *Senate Hearings before the Committee on Appropriations, fiscal year 1976*, pt. 1, Justification, 1975, p. 683.

remedial action is taken. In this latest stage of the investigation, some 325,000 tons of sand were injected under some 30 acres of land in the two most threatened areas of the city.[15]

In the program for *Control of Fires in Coal Deposits*, four fires were successfully brought under control, in Colorado, Montana, and Utah; the Utah project represented the sixth and final phase of a long-range control project.

In the program of *Engineering and Environmental Investigations*, the following were accomplished:

—A report, "Environmental, Economic, and Social Impacts of Mining Copper-Nickel in Northeastern Minnesota," was completed and placed in open file.

—The trans-Alaska pipeline has been the subject of two reports: (1) "Mineral Resources of the Trans-Alaska Pipeline Corridor" [16] and (2) "Impact of a Natural Gas Pipeline on Mineral and Energy Development in Alaska"—which is still in preparation.

In the program of *Wilderness Mineral Studies*, the joint Bureau of Mines/Geological Survey publications on the Idaho and Wilson Mountain-Uncompahgre Primitive Areas were instrumental in the development by the U.S. Forest Service of the final management proposals for those areas.

F. A LOOK AHEAD

The areas of effort programed by the Bureau of Mines for the next several years have been identified and discussed in detail in a recent internal report.[17] The rationale behind the Bureau's far-seeing program, and brief descriptions of the anticipated programmatic effort are described in the following paragraphs.

The Bureau, together with other agencies in the Department of the Interior, the National Commission on Materials Policy, the National Academy of Engineering, and the National Science Foundation, have all recognized that broad-scale mineral problems have arisen that are not only national but also international in scope, and thus are of major concern to the United States. These minerals problems are mostly interrelated, and their effects are felt alike by mineral producers and consumers—which means U.S. society as a whole. These problems may be grouped into five areas of concern:

A—U.S. dependence on imported minerals;

B—Inadequacies in availability of domestic minerals;

C—Development and maintenance of efficient production of minerals and materials, within social and environmental constraints;

D—Market instability for minerals and materials; and

E—Efficient utilization of minerals and materials.

The Bureau has developed a set of nine strategic objectives, in order to resolve or reduce the impact of these five problems, as follows:

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[15] $1.5 million has been made available to the Bureau in fiscal year 1976 for the completion of this project.
[16] Mulligan, John J., *U.S. Bur. Mines Inf. Circ. 8626*, 1974, 24 p.
[17] "Bureau of Mines Five-Year Strategic and Tactical Plan for Minerals:" Prelim. Draft, November 1: 1975, approx. 300 p.

1—Increase productivity/production in minerals and related materials industries;

2—Reduce waste of minerals and energy,

3—Expand availability of minerals,

4—Improve reliability and utilization of data and analysis;

5—Enhance safety and health of workers;

6—Reduce social and environmental costs;

7—Minimize vulnerability of supplies;

8—Improve response to demand for domestic minerals; and

9—Promote a national manpower pool that will be needed for the increased production and utilization of domestic minerals.

Each of these nine objectives has significant impacts upon at least one of the five problem areas, as shown in Table 7.

TABLE 7.—MATRIX OF THE 5 MINERAL PROBLEMS AND THE 9 OBJECTIVES FOR THEIR SOLUTION

	A. Imports dependence	B. Domestic availability	C. Efficient production	D. Market instability	E. Efficient utilization
1. Increase productivity	×	×	×		
2. Reduce waste			×		×
3. Expand availability	×	×		×	
4. Improve data and analysis	×	×	×	×	×
5. Enhance safety and health			×		
6. Reduce social and environmental costs			×		×
7. Minimize supply vulnerability	×			×	
8. Improve demand response		×		×	
9. Promote manpower pool		×	×		×

Note: In the following paragraphs, the several sub-objectives that are contemplated by the Bureau for each of these 9 objectives are listed.

Objective 1—Increase productivity/production in minerals and related materials

The Bureau will attempt to develop and transfer technology that can be used to increase mineral production and productivity. Several of the Bureau's mining and metallurgy subobjectives are:

Mining: Coal (a) Improve mine-development systems, to decrease the time needed to bring a mine into production;

(b) Automate longwall and continuous miners; and

(c) Improve roof-support systems and coal-transport methods.

Mining: Metal and nonmetal (a) Improve mining technology;

(b) Enhance the feasibility of mining of mineral deposits that are presently marginal; and

(c) Maximize the extraction and recovery of mineral resources.

Mining: Oil shale (a) Develop surface and underground mining technology for the complete recovery of oil shale deposits in the West; and

(b) Develop acceptable methods for the disposal of waste materials from oil shale retorting.

Mining: Explosives (a) Conduct investigations into the safety of explosives; and

(b) Improve the safety of the use of explosives.

Metallurgy (a) Develop innovative methods to recover metals and minerals, maximizing efficiency and minimizing pollution; and

(b) Develop wider uses of abundant minerals, and investigate substitutes for scarce minerals.

Objective 2—Reduce waste of energy and minerals

Waste of minerals can occur at every stage of the total materials cycle, from mining to final discard (see fig. 13), and progress must be made to reduce waste at each stage. Specific mining and metallurgy subobjectives for this purpose are:

Mining: Coal (a) Develop methods of mining deep Western coal deposits;

(b) Recover methane gas commercially from both mined-out and unmined areas; and

(c) Improve recovery by upgrading existing surface and underground mining technology.

Mining: Metal and nonmetal (a) Improve feasibility of mining mineral deposits that are marginal;

(b) Improve the technology for recovering and utilizing the valuable constituents in scrap that are discarded currently;

(c) Develop improved materials and metals that are suitable for use and avoid deterioration under adverse conditions, such as high temperatures or corrosive environments;

(d) Develop processes that use less energy or use low-cost energy sources; and

(e) Develop new or improved methods to recover waste products from mineral-processing plants.

Objective 3—Expand availability of minerals

Depletion of deposits mineable at low cost as compared to those available in underdeveloped countries has been partly responsible for reduced domestic mineral availability in recent years. In addition, the diminished availability of mineral-bearing land because of urban spread and the reservation of land for special uses, together with the increasing costs due to attempts to prevent environmental pollution and waste, have been partly responsible. Thus, trade deficits in nonfuel minerals and prices for many minerals are increasing. The Bureau's sub-objectives are the same as those listed under objectives number 1 and 2.

Objective 4—Improve reliability and utilization of data and analysis

Improved monitoring of the minerals industry and related activities could enhance the Nation's awareness of emerging mineral problems and opportunities, so that early action could be taken by both the Federal Government and industry to forestall or reduce the severity of these problems that have national significance. In addition, this improved information would help guide the Bureau's research program, which is also intended to minimize the impact of such problems.

Objective 5—Enhance safety and health of workers

At present, technological inadequacies exist in a number of metal-mine safety areas—such as industrial hazards, ground control, mine rescue and recovery operations, and fire prevention and control. Health problems are associated with dust (silicosis) and radiation (cancer). In addition, the current demand for metals and minerals has encouraged mining operations to take place in orebodies of lower grade and having less satisfactory physical conditions—such as increased rock pressure on mine openings because of depth, rock

that is inherently weak, and elevated temperature and humidity, all of which contribute to increased hazards for safety or health.[18]

The interaction between these health and safety matters and the lower productivity from underground coal mining in recent years should be recognized. If coal production is to be increased significantly by 1985—as projected by Project Independence and related energy studies—the numbers of injuries and deaths to miners are likely to increase unless health and safety advances are made at the same time.

Objective 6—Reduce social and environmental costs

The external costs of reducing air and water pollution, land-use conflicts, waste disposal, metals toxicity, and mined area reclamation must be balanced against the need for production of minerals. In recent years the desire of the public for improved environmental quality has placed severe constraints on the processing of minerals, because in many instances adequate control measures simply do not exist and in other, compliance with pollution-control regulations can be achieved only through the use of high-cost devices or the curtailment of production.

Additional social and environmental concerns require that the Bureau develop new and improved techniques for correcting environmental and public-safety problems that have resulted from past mining activity. Furthermore, the Bureau will try to prevent similar problems in current and future mining, such as

—subsidence control;
—stabilization of waste banks by physical and vegetative means;
—extinguishing of fires underground, in the outcrop, and in mine-refuse piles;
—reclamation of mined land; and
—sealing of abandoned oil and gas wells.

The Bureau recognizes that current knowledge is limited with regard to the ranges of tolerance and the nature of harmful effects that different concentrations of certain minerals cause when they come into contact with plants, animals, and people. Therefore, the possibility must be faced that regulations may be established which are either too weak or too restrictive.

Objective 7—Minimize vulnerability of supplies

This objective involves both the United States' economic position and its national security, as they are threatened by disruptions to foreign mineral supplies. Severe curtailment or complete interruption of such supplies could have adverse effects not only in the short term (3–5 years), but could cause enormous adjustments in physical supply and financial areas—although in the long run the United States could develop supplies from its own potential resources or possibly through diversification of foreign sources.

The United States imports 100 percent of its requirements for five significant mineral commodities—chromium, cobalt, columbium, manganese, and platinum—and it imports almost all of its requirements for 10 additional ones. All of these are important to the industrial base of a developed Nation such as the United States.

A key element in this vulnerability issue is the ability to forecast with confidence just when and where these disruptions in mineral

[18] The magnitude of these problems is seen by the 140 coal-mine fatalities per year (185 in metal and nonmetal mines), the 11,000 coal-mine injuries per year (12,000 in metal and nonmetal mines), and the $965 million compensation paid to coal miners in 1974.

supply would occur, their nature, and which minerals would be affected. Forecasting is, of course, dependent on the input of accurate information and data.

It is clear that many foreign policy and trade issues are involved, so the full implementation of the Bureau of Mines strategy will involve cooperative efforts with several other Federal agencies and authorities.

Objective 8—Improve response to demand for domestic minerals

The Bureau document notes that, although the United States has only 6 percent of the World's population, it consumes 31 percent of the World's mineral production. The United States does produce 25 percent of the World's minerals, but the domestic demand has driven the United States increasingly to the use of lower grades of deposits, which makes it ever more difficult to keep up with demand. Moreover, changes in demand for specific minerals, caused by the new ways of using as end products materials that are based on minerals, continue to put pressure on producers of minerals and materials.

This objective considers issues that will contribute to meeting the changing demand for domestic minerals, while at the same time minimizing the unwanted effects of instability in the minerals market—especially wide fluctuations in price.

Objective 9—Promote a national manpower pool, adequate for the increased production and utilization of domestic minerals

Whereas objectives 1–8 point the way toward substantial increases in domestic minerals production, they sidestep the issue of the adequacy of the national pool of professional and nonprofessional manpower that will be needed to bring about these increases.

Since industry uses the manpower and produces the minerals, its view on future production increases and manpower needs must be obtained, together with knowledge on the extent to which the objectives of the minerals industry coincide with those of the Federal Government.

In the coal industry, a Federal goal of doubled production by 1985 has been set by Project Independence, which will involve some 400-500 new mines in that 10-year period. In June 1975 the U.S. coal-production work force was 168,000 people, whose productivity has been declining in recent years. Although advanced technology will likely result in greater productivity, it is obvious that a tremendous increase in coal manpower will be required by 1985, and the required level must be estimated more closely. In addition, the 400–500 new mines will require substantially increased professional manpower, for their design and development.[19]

For minerals and materials other than coal, increased production and technology needs will encounter the same kind of manpower problems. but rigorous analysis and projections have not yet been undertaken,

The Bureau recognizes that it, alone, cannot pursue the strategies to meet these objectives and overcome these problems. Rather, the cooperative efforts of numerous governmental agencies, the scientific community, and industry will be necessary.

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[19] Professional manpower-development rates for the mining and materials sciences have been declining steadily for many years—from 1,813 bachelor's degrees in 1957 to 1,280 in 1974 according to data developed by the National Academy of Sciences and the National Association of State Universities and Land-Grant Colleges. The number 1,280 is only one-tenth of 1 percent of all bachelor's degrees awarded in 1974.

V. Some Recent Criticisms and Erosion of Bureau of Mines' Programs

A. THE HELIUM PROGRAM

Introduction

The helium-conservation program was inaugurated in 1961, because increasing helium demands were expected to outstrip the Bureau's production capacity, to conserve helium that was being wasted when natural gas containing it was burned for fuel. Conservation of helium was given high priority because of the military importance of that nonflammable gas; helium is also useful for medical, scientific (especially low-temperature reactions), and commercial purposes.

> The helium conservation program is a national disgrace, and I have been trying to find somebody in the administration who would have the guts and the willpower to admit that a mistake has been made.
>
> It started with OMB . . . deciding it was not economically feasible to continue a program established by Congress and that the payoff was going to be bad so, they unilaterally, without congressional action, canceled contracts, or undertook to cancel contracts because the court has said, "You cannot do it."
>
> So the helium, which is being separated from the helium-rich gas streams, is now being vented to the air, and the Government is required to pay for it. That is neither a conservation nor an economic measure . . . We are wasting an asset, and we are wasting hundreds of millions of dollars of the taxpayers' money.[1]

That criticism of the U.S. Government's helium program was directed at Thomas S. Kleppe during his confirmation hearing as Secretary of the Interior, in September 1975. However, the usual recipient of such criticism of the helium program has been the Bureau of Mines, which is required by law to administer it.

The helium program, which has been under way for 50 years,[2] was causing concern more than 35 years ago, for on February 23, 1938, Interior Secretary Ickes recorded that he had "not been satisfied with the way the Bureau of Mines has been handling this helium matter."[3]

History

Helium was seen as important militarily by the U.S. Government in 1917, after the raids on England and the European Continent by the German Zepplins. The first full-scale helium plant in the United States was built in 1921 by Linde Air Products Co., which operated it under contract with the U.S. Navy until July 1925, when the jurisdiction of all U.S. helium activity was transferred to the Bureau of Mines.[4]

Helium from U.S. Government plants was not sold to non-Federal users until 1937, when the Helium Act[5] provided for the sale of helium for medical, scientific, and commercial uses. However, it was

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[1] Remarks by Senator McClure, "Interior Nomination [of Thomas S. Kleppe as Secretary]": Hearings, Senate Committee on Interior and Insular Affairs, September 23, 1975: 94th Cong., 1st sess., p. 25.

[2] Public Law 68-544 (Helium Act of March 3, 1925), amended by Public Law 69-758.

[3] Ickes, Harold L., "The Secret Diary of Harold L. Ickes, volume II, The Inside Struggle, 1936-39;" New York City, Simon & Schuster, 1954, p. 325.

[4] Laverick, Charles, "Helium—Its Storage and Use in Future Years; Preliminary Report": Argonne National Laboratory Rept. ANL/EE-75-1 for the Energy Research and Development Administration, 1975, p. 36.

[5] Public Law 75-411.

not until World War II that the great impetus began for large-scale production of helium for helium-filled blimps to protect convoys of ships carrying materiel and troops.

Near the end of World War II, helium-shielded arc welding was developed, providing a new use for large quantities of that inert gas. The U.S. space program "could probably not have been carried out without the use of helium, and at the 1966 peak in helium consumption, more than 60 percent was used in this way." [6] Thus, one factor in making the U.S. space program possible was the U.S. Helium Conservation Program.

Helium conservation program

In 1957, when increasing helium demands were threatening to outstrip the production capacity of the Bureau of Mines, concern arose about the future ability of the Bureau to meet the U.S. mobilization needs and because this natural resource was being wasted when natural gas containing helium was burned for fuel. The Director of the Office of Defense Mobilization recommended to the Secretary of the Interior that a working group on helium be established, to determine the feasibility of raising the conservation aspect of the helium program to the status of its primary objective rather than merely an incidental one.

As a result of the study [7] prepared by the working group [8] that was established, a national helium conservation policy was subsequently recommended to President Eisenhower, who approved it on April 25, 1958. Because of the huge expense required to accomplish the program, the Chilson report recommended that:

(1) Private industry be encouraged to participate by entering into long-term contracts with the Government;

(2) The Secretary be authorized to set the price for helium at a level which would cover all costs incurred;

(3) All Federal agencies and contractors purchase all major helium requirements from the Secretary; and

(4) The private companies participating in the program be prohibited from selling helium to any purchaser other than the Secretary, at a lower price than that paid by any Government agency.

In 1958 the Department of the Interior proposed legislation to implement this recommended helium-conservation program. However, as it was not acted upon, redrafted proposals were submitted to the Congress on July 27, 1959. After lengthy hearings, and revisions and amendments to the proposed bill, it was adopted on September 13, 1960, entitled "An Act to Amend the Helium Act of March 3, 1925, As Amended, for the Defense, Security, and the General Welfare of the United States." It became effective on March 1, 1961, and a limitation on the annual contracting authority of $47.5 million was established by a subsequent act.[9]

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[6] Laverick, 1975, p. 36.

[7] Chilson, O. Hatfield, "Cost and Implementation of a National Conservation Policy," Report to the President, Jan. 24, 1958, 20 p.

[8] Consisting of representatives from the Atomic Energy Commission, Bureau of the Budget, Department of Commerce, Department of Defense, Department of the Interior, Federal Power Commission, and Office of Defense Mobilization.

The 1960 Helium Act amendments authorized the Secretary of the Interior to:

(1) Enter into long-term contracts, not to exceed 25 years, for the acquisition, processing, transportation, and conservation of helium;

(2) Acquire, by eminent domain, helium contained in helium-bearing natural gas and also as much of such gas as was removed necessarily in the extraction process (if he were unable to acquire helium otherwise on reasonable terms and at fair market value).

As recommended in the Chilson report, the Secretary was authorized to set his own price for the helium that he sold, and to promulgate necessary rules and regulations.

All costs of the program were to be paid out of income derived from the sale of helium. All borrowed funds, and the Government's investment in capitalized property had to be repaid, together with accrued interest, within 25 years.[10]

Annual contracting authority of $47.5 million for helium purchase was approved in 1961 by the Congress, and by November 1961 four fixed-price, 22-year, take-or-pay contracts were signed.[11]

Helium program, 1969

In 1968, nearly all of the free world's production of 4,880 million cubic feet came from the United States, with Canada supplying about 25 million cubic feet, less than 1 percent of the total; helium production began in France in 1969. In addition, the U.S.S.R. was reported to be producing 70 million cubic feet per year.[12] The U.S. supply came from plants of the Bureau of Mines (14 percent) and of private industry (8 percent), and from conservation plants (78 percent). This supply was distributed among current U.S. demand (842 million cubic feet or 17 percent) and exports (25 million cubic feet or one-half percent), and the rest (3,988 million cubic feet of 82½ percent) went to storage.

Principal users of helium in the United States in 1968 were several Federal agencies (720 million cubic feet or 86 percent of the 17 percent), National Aeronautics and Space Administration, the Department of Defense, and the Atomic Energy Commission; non-Federal users acquired the remaining 122 million cubic feet (14 percent of the 17 percent).

On June 30, 1969, 6 years after the U.S. Government's helium conservation program began, some 22 billion cubic feet was in conservation storage. Projected U.S. demand (annual growth rate of 1.5–4.5 percent)[13] shows that in the early 1980's, withdrawal of stored

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[9] Public Law 86-777, 75 Stat. 246, 253.

[10] This payout period could be extended by 10 years, if necessary.

[11] With National Helium Corp., Northern Helex Co., Cities Service Helex, Inc., and Phillips Petroleum Co.

[12] Lipper, Harold W., "Helium," p. 79-95 of "Mineral Facts and Problems," 1970 edition: U.S. Bureau of Mines. More recently, the Energy Research and Development Administration has reported that annual foreign helium production as of January 1975 is: Canada, 36 million cubic feet; France, 15 million; Poland, 150 million (estimated); and Eastern Europe (principally U.S.S.R.), 70 million (estimated). (ERDA, "The Energy Related Applications of Helium": ERDA–13, Apr. 10, 1975, pp. 75–80). In addition, the ERDA report presented a table showing helium concentrations in foreign gas fields, and it discussed an Algerian gasfield whose gaseous waste stream contains 5 percent helium, which is very economical to recover. The ERDA report concludes, therefore, that substantial supplies of relatively low-priced helium could be produced from foreign sources of natural gas through the year 2000, and that the United States could possibly supplement its domestic resources with imported helium during that period. Soon after the turn of the century, says the ERDA report, foreign demand (like that of the United States) is expected to exceed supply, and a worldwide supply problem with rapidly increasing prices is expected to develop around the year 2020.

[13] Lipper, 1970, p. 89.

helium would have begun, and by the year 2000 all of the stored helium would have been used. Furthermore, meeting the cumulative projected demand for the rest of the world by the year 2000 would surely be difficult unless new and richer [14] sources are discovered outside the United States.[15]

Until late in 1961, the only helium-extraction plants in the free world were owned and operated by the Bureau of Mines. Since then, private industry has constructed five plants, which supply helium for conservation under four 22-year purchase contracts with the Department of the Interior. Furthermore, by 1969 private industry had built in the United States seven new plants, which operated outside the Government's helium program—although three of the seven were closed in September 1969.

The four helium-purchase contracts between the Bureau of Mines and the four private firms provide for purchase of about 3.5 billion cubic feet of helium per year, and will aggregate about 62.5 billion cubic feet in their 22-year life, under the presently authorized program of $47.5 million per year. Of the 62.5 billion cubic feet, the Bureau of Mines expects to sell 21 billion cubic feet and place the remaining 41.5 billion cubic feet in storage for use after 1983 when the contracts expire.[16]

The price aspect of U.S. helium production and sale has been a major element in the helium controversy. On November 1, 1961, the price of helium at the plant was increased to $35 per 1000 cubic feet,[17] in order to finance the long-range helium-conservation program. The seven private helium plants brought their price at the plant down to $20 to $25 per 1,000 cubic feet, and thus encroached on the Federal market which was reserved to the Government by the Helium Act of 1960.

However, the Act does not specify that contractors doing work for the Federal Government must purchase from Government plants. In October 1968, the Department of the Interior issued revised regulations that would have required contractors on Federal jobs to buy the higher priced Government-produced helium. The authority of the Interior Secretary to so regulate Government contractors was challenged by three of the seven private producers, and the Secretary was enjoined on December 9, 1968, from applying the new rules. The Secretary appealed, but on September 22, 1969, the injunction was upheld.

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[14] Helium does occur in other gases in Europe, Africa, South America, and Asia, but the content is low (0.2 percent or less); it can be recovered as a byproduct, although expensive (see footnote 1).

[15] Lipper (1970, p. 82) says that in 1969 gases containing less than 0.3 percent were not considered economic for helium recovery. Resources of helium of this grade or better in the United States as of January 1, 1969, totaled 165 billion cubic feet. (But only 135 billion, or 82 percent, of those reserves were considered economically recoverable because the gases are either noncombustible or have such low heating value as to be nonmarketable for fuel use, and for other reasons). Helium resources in Canada are estimated to be 1.2 billion cubic feet.

Lower-grade helium resources in the United States have been estimated, giving a total of 937 billion cubic feet of "proved, probable, possible, and speculative resources"; however, as their grade ranges from 0.006 to 0.278 percent, they cannot be considered accessible under present conditions of technology and economics. The U.S.S.R. has some helium, especially in eastern Siberia where the helium content is reportedly 1 percent (Lipper, 1970, p. 83), although its current production is said to be coming from natural gas that contains only 0.05–0.07 percent. (Lipper, 1970, p. 80).

Recovery and reuse of helium is not practiced in the United States, as losses are small; however, in the future, "recovery and reuse will probably be preferred to extraction from lean helium resources." (Lipper, 1970, p. 84.) Recovery and reuse does take place in the rest of the free world (United Kingdom, West Germany, France, Japan), which use approximately 50 million cubic feet of helium per year (imports from Canada and the United States); because of the high price of helium in those countries ($250 per 1,000 cubic feet), helium is used sparingly and is captured and reused again and again. (Lipper, 1970, p. 90.)

[16] Lipper, 1970, p. 89.

[17] Previously, the price had been $15.50 to Federal purchasers and $19.00 to non-Federal purchasers.

Loss of the Federal contractor market reduces income required to liquidate the costs of the helium conservation program as required by law and poses a severe threat to completing the program originally as planned.

The helium-price situation as it existed in mid-1969 suggests that achieving full potential for beneficial use of the Nation's helium resources requires a new look at means for achieving conservation of wasting helium resources and for financing such conservation . . .

Although the arrangement for financing the Government helium conservation program requires that all helium purchased for conservation be paid for out of income from helium sales by 1995, the shared helium should be sold at a price which reflects its cost. Depending on average interest rates, this cost will probably be $50 to $75 per thousand cubic feet. . . .[18]

Helium program as seen by the Bureau, 1975

The Federal Government's helium program, conducted by the Bureau of Mines under the Helium Act of 1960, has as its major purpose to provide "a sustained supply of helium which . . . will be sufficient to provide for essential Government activities".[19] It was also the sense of the Congress, however, "that it is in the national interest to foster and encourage individual enterprise in the development and distribution of helium." [20]

The position of the Bureau of Mines [21] is that the Helium Act—

was not designed to encourage conservation based upon speculative possibilities as to the needs of essential Government activities so far in the future as to be wholly conjectural. It seems even clearer that the Helium Act was not designed to conserve helium for speculative needs in the private sector at some specified time in the 21st century.

The Bureau's program is carried out through its Division of Helium at the National Headquarters. A field manager is located at Amarillo, Tex., and plant facilities and personnel are located at the three Bureau plants in Texas, Oklahoma, and Kansas. Staffing of the program in fiscal year 1976 involves 245 positions, and receipts and expenditures for the year are estimated at $7.7 and $7.4 million, respectively.

As of June 30, 1975, the Government had invested $534 million in the helium program, of which $412 million is owed to the U.S. Treasury. During 1976 the Bureau proposes to repay $1 million of net-worth debt to the U.S. Treasury.

The Bureau's program has been one of conservation and production of helium, to meet the long-term needs for essential Federal programs. The Bureau provides users with helium; the helium users, themselves, have conducted the research and development necessary for end-use applications. The Bureau's R. & D. activities have been directed toward discovering new sources of helium, and developing more efficient processes for helium extraction, purification, and distribution.

In the *conservation* area, as of June 30, 1975, the Bureau had 38.35 million cubic feet of helium instorage [22], [23] at its Amarillo storage reservoir, of which 30.4 million was Government-owned, 0.94 million was stored for others, and 7.0 million was accepted under a court-ordered injunction.[24] As another part of the Bureau's conservation

[18] Lipper, 1970, p. 88.
[19] Public Law 86-777; 50 USC 167-167N, in, Sec. 15.
[20] *Ibid.*
[21] USBM, "The Bureau of Mines Helium Program, August 27, 1975," Bur. Mines Position Paper, Mimeo, 12 p.
[22] At present, the Government is not purchasing any helium for storage although authorized by th. Helium Act; however, the Bureau is storing its excess helium production—at a rate of 150 million cu. fte per year plus about 600 million cubic feet from private plants
[23] The Amarillo storage reservoir (Cliffside Field) actually contains 42.1 million cu. ft. of helium; the 3.75 extra is helium that is contained in the natural gas that remains in the reservoir.
[24] For a summary of the status of litigation, see Table 8.

responsibilities, it maintains the Cliffside storage reservoir and associated pipelines and monitoring services. In addition, the Bureau conducts surveys of the United States and foreign countries to discover new sources of helium, and evaluates current and potential reserves related to the helium program needs.

In the area of *supply/demand*, the Bureau is aware that not only does natural gas contain helium, but also the atmosphere does. However, since recovery of large quantities of helium as a primary product from the atmosphere is unattractive at present, for both economic and energy reasons, the Bureau is devoting its attention to the recovery of helium from natural gas—principally fuel gas. The Bureau and Stanford Research Institute have made projections of total future U.S. demand for helium, which range for the year 2000 from the Bureau's 1.4–3.6 billion cubic feet to SRI's 5 billion; the disparity in these estimates, the Bureau feels, should not be a cause for concern, because of "the uncertainties of the future and the experience of the past years [suggest that] it would not be realistic to attribute a high degree of reliability" to either estimate. Actually, the use of helium during the period 1970–74 was well below the amounts that had been projected "in any of the estimates for [those] years."

As of January 1, 1975, the Bureau estimated that "proved" reserves of helium in helium-rich natural gas were 111 billion cubic feet, and that an additional 13 billion cubic feet is present in "shut-in" fields. "Probable" shut-in reserves of helium-rich natural gas are 41.7 billion cubic feet. In addition, 38.4 billion cubic feet of helium is stored in the Cliffside Field at Amarillo, which also contains a residue of 3.7 billion cubic feet in the native gas remaining in that field when Government storage operations began. Also, the Bureau estimates that 3.5 billion cubic feet of helium will be recovered in its Keyes plant (through an exclusive life-of-the-field gas-supply agreement). Thus, the Bureau reports an "assured" supply of 45.6 billion cubic feet of helium, plus a "probable" 41.7 billion cubic feet, for a total of 87.3 billion cubic feet.

Regarding demand, in 1972 the five major helium-using Federal agencies (NASA, DOD, AEC, Weather Bureau, National Bureau of Standards) estimated their helium needs through the year 2000 as being 6.2 billion cubic feet. Thus, the Government's "assured" supply of 45.6 billion cubic feet would be seven times as great as needed.

Current litigation

Several lawsuits have been filed, involving the Bureau of Mines helium program, and 10 of them are in various stages of litigation. The elements of these cases and the action to date is summarized in Table 8.

TABLE 8.—SUMMARY OF CURRENT LITIGATION PERTAINING TO THE BUREAU OF MINES HELIUM CONSERVATION PROGRAM

Case	Purpose	Parts	Action
1. Northern Natural Gas Co., et al. v. Ralph Ground, et al.	To determine title to helium in natural gas produced by lessees from lands of landowners, which was then extracted from the natural gas by Helex Co. and then sold to the United States.	(a) Helex Cos. brought action against holders of mineral rights and producers.	(a) Apr. 15, 1969, U.S. District Court for Kansas entered judgment for Helex Cos. Mar. 2, 1971, U.S. 10th Circuit Court of Appeals reversed District Court judgment. July 17, 1972 District Court granted U.S. motion to intervene as plaintiff. Trial, March 1974 held to determine value of helium in natural gas before extraction; Nov. 12, 1974 Court ruled that it ranged from 614 to 1,000 ft³ in 1962 to 704 in 1972. This ruling has been appealed to the U.S. 10th Circuit Court.
		(b) Cross claims and counterclaims by latter against the United States. Re: (1) U.S. conversion of helium owned by landowners, and (2) U.S. exercise of eminent domain against landowners.	(b) Apr. 15, 1969, U.S. District Court entered judgment for the United States Mar. 2, 1971, U.S. 10th Circuit Court of Appeals affirmed District Court judgment.
2. Ashland Oil Inc. v. Phillips Petroleum Co.	To determine the reasonable value of helium contained in natural gas (United States is interested, because the contract provides that it must indemnify Phillips for payments to third parties in excess of $3 per 1,000 ft³.)		The U.S. District Court for Northern Oklahoma found the value to be $12 to $17 per 1,000 ft³. The decision was appealed to the U.S. Circuit Court of Appeals, which upheld the District Court's decision. Defendant has petitioned the Court of Appeals for a rehearing.
3. Amoco Production Co. v. Phillips Petroleum Co.	do		Case in State Court for Amarillo County. The United States has been permitted to intervene.
4. Cities Service Oil v. Phillips Petroleum Co.	do		Case in the U.S. District Court of Tulsa County, Okla.
5. Texaco, Inc. v. Phillips Petroleum Co	do		Case in U.S. District Court, Tulsa County, Okla.
6. Northern Helex Co. v. United States	To recover damage for breach of contract of Aug. 15, 1961 by United States, for sale and purchase of Helium-gas mixture; damages of $92,000,000 requested. (Court of Claims decision had held that the United States had breached the contract by failing to make payments on time, justifying the contractor to consider the contract terminated).		Suit filed Dec. 24, 1970; the parties presented their cases on damages, in March and April 1973. Trial judge held on Dec. 3, 1974 that the company is entitled to $78 000,000, this is subject to review by the full Court of Claims, and oral argument was held in June 1975. The award was reduced to $35,000,000 by the Court on Oct. 22 1975, and was returned to the Trial Judge for further reduction.
7. Cities Service Helex, Inc. v. United States	do		On Apr. 24, 1975 suit filed in U.S. Court of Claims.
8. National Helium Corp., et al. v. Morton, et. al.	To prevent termination of conservation helium sales contract by United States.		Plaintiff petitioned U.S. District Court (Kansas) for injunction against Secretary of the Interior and Bureau of Mines Director on Mar. 17, 1971; Phillips Petroleum Co. and Cities Service Helex, Inc., intervened for plaintiff. After hearing on Mar. 27, 1971, the court temporarily enjoined defendents from terminating contracts with the 3 companies pending further court order. U.S. appealed to U.S. 10th Circuit Court of Appeals, and on Oct. 4, 1971, the Circuit Court affirmed the District Court judgment (because the Secretary had not foollwed NEPA requirements). Pursuant to sec. 102(2)(c) of the National Environmental Policy Act of 1969, the Bureau of Mines issued a draft statement on Mar. 16, 1972, and a final statement on Nov. 13, 1972, entitled "Termination of Helium Purchase Contracts."

TABLE 8.—SUMMARY OF CURRENT LITIGATION PERTAINING TO THE BUREAU OF MINES HELIUM CONSERVATION PROGRAM—Continued

Case	Purpose	Parts	Action
			On Feb. 2, 1973, the Secretary notified the 3 companies that the contract would terminate on Apr. 4, 1973. However, the district court continued the injunction against termination (because the Bureau of Mines' environmental impact statement was inadequate). On Oct. 19, 1973 the Circuit Court reversed that ruling, and on Nov. 12, 1973 the United States ceased accepting helium from the 3 companies. On May 13, 1974 the U.S. Supreme Court declined to review the Court of Appeals decision. Late in 1974, the Interior Department began negotiations with the 3 companies to settle the contract-termination issues; however shortly after negotiations were begun, decisions were handed down in 2 lawsuits that had adverse effects on the possibility of reaching a settlement. Accordingly, negotiations were discontinued and 2 of the companies (Cities Service Helex, Inc. and National Helium Corp.) filed suit (see cases No. 7 and 8a). The 3d company (Phillips Petroleum Co.) has taken no action to date (Aug. 27, 1975).
8a. National Helium Corp. v. United States	For breach of contract by United States; damages of $171,000,000 claimed.		On May 12, 1975, suit filed in U.S. Court of Claims; no action to date.
9. Airco, Inc. v. Morton, et. al	To contest the interpretation by the Bureau of Mines of the Interior Secretary's regulations, which the company interprets differently. (The Secretary's regulations, required by the Helium Act, require helium distributors to report their Federal sales to the Bureau as well as their purchases of Bureau Helium. Reports are made each 6 mo, and the distributor must make up the difference between its sales to Federal agencies and its purchases from the Bureau. Airco was found by the Bureau to be out of balance during the 1st 6 mo of 1974. Airco appealed to the Board of Contract Appeals, and filed suit.)		Suit filed in the U.S. District Court for Southern New York.
10. Caroline Bush Emeny, et. al. v. United States.	To gain just compensation by landowners for United States taking by eminent domain the storage rights in Bush Dome of Cliffside Field in Potter County, Tex.; United States countered that it had storage rights because of gas rights it had acquired from landowners' predecessors years ago.	(a) Initially: was the right to store helium in Bush Dome vested in United States or landowners? (b) Subsequently: what is the value of storage rights?	(a) U.S. Court of Claims decided for landowners. (b) U.S. Court of Claims received presentations in June and July 1970; values claimed ranged between $2,000,000 by landowners to zero by United States (zero to anyone other than owners of the gas rights.) Commissioner's report of May 13, 1971 gave a just compensation of $152,000 plus 4 percent interest from Jan. 5, 1963; because plaintiff objected and presented written briefs and oral arguments, the Court remanded the case to Trial Commissioner for additional findings and explanation, whose revised report of Oct. 19, 1972 revised the compensation to $222,000 plus the same interest; and the Court adopted the report. Plaintiffs subsequently filed claims for litigation costs of $350,000, and final settlement is pending.

Case No. 1 involves helium-extraction companies whose plants are located in Kansas—Cities Service Helex, Inc.; National Helium Corp.; and Northern Helium Co. Cases No. 2–5 involve the other helium-extraction company (Phillips Petroleum Co.), whose two plants are located in Texas. All five cases deal with determining the reasonable value of helium in natural gas that is delivered to the helium-extraction plants.

Cases No. 6–8 deal with the charge of breach of contract by the United States for the sale and purchase of a helium-gas mixture. Case No. 9 concerns the reporting to the Bureau of Mines by private helium distributors of their sales of helium to Federal agencies, and Case No. 10 deals with obtaining just compensation for storage rights in an oilfield that had been taken by the United States through exercise of the power of eminent domain.

A list of the titles of the three other cases, for which litigation has been completed, is given in appendix VI.

The energy view, 1975

The Bureau of Mines looks at its helium-conservation program from the standpoint of all of its uses. In recent years the U.S. energy situation has focused attention upon the energy aspect of governmental programs, and the helium program has had its share of this energy attention.

The Energy Research and Development Administration was born a year and a half ago, mainly from the R. & D. elements of the Atomic Energy Commission and the Interior Department's Office of Coal Research, and shortly thereafter it initiated a study of U.S. helium policy. This study, which was transmitted to the President on April 10, 1975, was also the subject of a hearing before the House Science and Technology Committee on May 7, 1975.[25]

The ERDA report, "The Energy Related Applications of Helium," is a rather comprehensive document that consists of a 161-page report which includes eight appendixes and is backed up by a number of related reports.[26]

In his prepared statement and testimony before the subcommittee, Dr. James S. Kane (ERDA's Deputy Assistant Administrator for Conservation) made it clear that the issue today is not whether the old conservation program should be reinstated. Rather, he stated, the real issue is much more complex and therefore the old program could not be resurrected even if we wanted to—because "recent court decisions involving determinations of the value of helium and controversies over title to the helium contained in natural gas have altered the circumstances surrounding the extraction of helium. * * *"

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[25] "The Energy Related Application of Helium," Hearing before the Subcommittee on Energy Research, Development, and Demonstration of the House Committee on Science and Technology, Mar. 7, 1975: U.S. Congress, House, 94th Cong. 1st sess., Nov. 10, 1975, 576 pp. (ERDA testimony and statement included in pp. 1–28 and 53–576.)

[26] Laverick, Charles, "Helium—Its Storage and Use in Future Years (Preliminary Report)": Argonne National Laboratory, report ANL/EE 75–1, November 1974, 127 pp. plus three appendixes, as follows:

A. "Resolution of the President's Energy R. & D. Advisory Council Regarding the U.S. Helium Conservation Program," Sept. 17, 1974, 2 pp.

B. Evans, David M., "Helium Supply," Nov. 16, 1973, 10 pp.

C. Howland, H. R. and J. K. Hulm, "The Economics of Helium Conservation," final report of a study performed by Westinghouse Research Laboratories for Argonne National Laboratory, Dec. 19, 1974, 161 pp.

Laverick, Charles, "Helium—Its Storage and Use in Future Years." (Summary report: Argonne National Laboratory, report ANL/EE–75–2, January 1975, 15 pp.)

Dr. Kane cited the four recommendations of the ERDA report, as follows:

(1) The Federal Government should facilitate the storage of privately owned helium in Government-owned fields.

(2) The Federal Government should establish a helium-management and pricing policy consistent with the objectives of recommendation No. 1 and taking into account the benefits and costs to the public.

(3) The Federal helium program should continue to be administered by the Department of the Interior's Bureau of Mines.

(4) The Federal Government should improve our knowledge of how much helium exists in gas deposits that are not likely to be consumed [for fuel purposes].

Dr. Kane's statement noted that, after the year 2000, it is likely that advanced electric power technology options will become available, and that the three technologies which appear to be the largest potential users of helium are (1) superconducting power transmission, (2) superconducting magnetic energy storage, and (3) some types of fusion reactors.

Helium from the atmosphere

The helium content of the atmosphere is about 5 parts per million, and helium can be recovered therefrom. However, recovery of large quantities of helium from the atmosphere as a primary product is presently not attractive because of cost and energy requirements and pollution problems associated with energy generation.[27] The cost of extracting helium from the atmosphere is projected to range between $3,000 and $6,000 per 1,000 cubic feet, which is 150–300 times the present commercial price of helium ($20) and 85–150 times the price of Bureau of Mines helium ($35) that is being produced from existing plants.[28] In terms of energy, the cost of extracting helium would equal 16 percent of the current annual bituminous coal production of 600 million tons—a considerable cost.

The potential for recovery of helium from the atmosphere has been the subject of forceful testimony by Senator James McClure, before the House Committee on Science and Technology on May 7, 1975. He feels that "the Congress should consider immediately * * * the cost—both in terms of dollars and in terms of energy—for extracting helium from the atmosphere." [29]

His written statement expressed the hope that the ERDA Administrator "will continue to recognize the critical interrelationships between helium availability and the energy research for which he is responsible," and in his oral testimony he reminded the House Subcommittee that when the ERDA legislation was coming through he had supported an amendment which would have transferred the helium program from Interior's Bureau of Mines to ERDA.[30] Senator McClure continued that "the scientists in ERDA would have a better percep-

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[27] "The Bureau of Mines Helium Program": Position paper by USBM, August 27, 1975, p. 3-4.
[28] ERDA, "The Energy Related Applications of Helium": ERDA-13, April 10, 1975, p. xiii.
[29] Prepared statement. "The Energy Related Applications of Helium," Hearing, Subcommittee on Energy Research, Development and Demonstration of the House Committee on Science and Technology, U.S. Cong., 94th, 1st sess., May 7, 1975, p. 29-30. Senator McClure expressed his criticism of another element of the Government's helium program—"the decision of OMB to cancel the contracts under which helium was being extracted from natural gas and saved for future use," which is now being tested in the courts.
[30] Hearing, May 7, p. 34.

tion of the value of helium and its requirements for the future than would people under the current administration in the Department of Interior."

Recent action is illustrated by Senate passage on May 13, 1976 of a resolution (S. Res. 253, introduced on September 11, 1975 by Senators Domenici, Fannin, Hansen, McClure, and Bartlett) urging the President to "direct the Secretary of the Interior to make prompt arrangements to conserve the helium which is now being extracted and then vented into the atmosphere." A similar resolution (H. Res. 1215) was introduced in the House on May 25, 1976 by Congressman Sebelius.

B. ERDA AND FOSSIL FUEL RESEARCH, AND DATA COLLECTION AND ANALYSIS

Research

Since its inception in 1910, the Bureau of Mines has conducted research on bituminous coal, but until the middle 1940's it dealt mainly with health and safety aspects; research on lignite began in 1919, and on anthracite in 1945. Research on petroleum and natural gas by the Bureau began in 1915, and on oil shale in 1926. Fuel-testing of oil and gas had been an integral part of the program of the U.S. Geological Survey before 1910, and this was transferred to the Bureau in that year when the latter was spawned from the Geological Survey.

In 1960 the Office of Coal Research (OCR) was spun off from the Bureau and established in the Interior Department, "to develop new and more efficient methods of mining, preparing, and utilizing coal." [31] In late 1974 this office was absorbed into the newly created Energy Research and Development Administration (ERDA),[32] and the six energy research centers and the synthane fuel plant of the Bureau of Mines were also transferred to ERDA.

ERDA's fossil fuel program is to develop coal technology, including its chemistry, gasification and liquefaction, combustion, carbonization, and management of wastes and pollutants arising from coal's production and use. The work is performed by extramural contracts with universities, with industry, and with private research organizations.

The Bureau' six energy research centers, which had been established before the middle 1920's, are at Bartlesville, Okla. (petroleum); Grand Forks, N. Dak. (lignite and western coal); Laramie, Wyo. (oil shale and petroleum); Morgantown, W. Va. (coal, oil and gas); Pittsburgh, Pa. (bituminous coal and anthracite); and San Francisco, Calif. (oil in California fields). These centers, except for the one in San Francisco, were all located at universities and their research programs are carried out both by in-house Bureau staff and by cooperating university staffs and facilities and through contracts and other mechanisms.

Thus, some coal-research activities of the Bureau had been taken up by ERDA, but the Bureau retained others. On paper, ERDA's research activities and those of the Bureau are distinct, and therefore

[31] General Services Administration, *U.S. Government Manual*, 1973-74: Washington, D.C. Gov. Print. Offi. July 1973, p. 265.
[32] Public Law 93-438, The Energy Reorganization Act of 1974, sec. 104(e)(1) and (2).

overlap and duplication should not exist. However, the opportunity for confusion was built in, for the Report on the Act [33] said:

The activities remaining the the Bureau of Mines are, *for the most part,* not energy-related *in an R. & D. sense.* Energy-related work which will remain in the Bureau includes some of the mining technology research activities. Expertise in this area is essential for mining health and safety research and provides support required *to avoid disruption of the Bureau's remaining program.* This work will not be transferred because of its intimate relationship to other mining technologies. (Emphasis supplied.)

In addition to the indefinite nature of the italicized phrases and words in the above quotation, it would appear that the fossil-fuel research activities of the Bureau were thereafter to be restricted to those related to health and safety. This point had been stressed in testimony presented at the hearings by Carl E. Bagge, President of the National Coal Association:

. . . it is absolutely essential that you expressly provide for the transfer of the mining technology functions of the Bureau of Mines to ERDA, but not the health and safety functions.[34]

Bagge continued [35] that this relocation of the "mining extraction technology" function of the Bureau of Mines in the new ERDA is essential because:

You have to think of all this as a total delivery system and the Administrator of ERDA having concern for the gasification and liquefaction technology has to be able to manipulate the total system in such a way that he knows he has to turn on more in mining technology to accommodate new . . . technological breakthroughs involving coal.

However, both the House and Senate Committees on Government Operations, during consideration of H.R. 3474 (the Energy Reorganization Act of 1974), became aware that without some clarification of intent, the Act would authorize research and development work that would duplicate work being done in the Bureau of Mines. Accordingly, clarifying language was added to each committee report. The Senate report says:

Research on coal mining technology, including coal analysis and preparation, as well as the use of coal for metallurgical processes will be *continued by the Bureau of Mines,* especially as such research relates to mining and metallurgical technology or mine health and safety. . . . These include responsibility for mining metals and minerals, mine health and safety, mined area reclamation. (Emphasis supplied.)

And the House report says:

Energy-related work which will *remain in the Bureau* includes some of the mining technology research activities. Expertise in this area is essential for mining health and safety research and provides support required to avoid disruption of the Bureau's remaining program. This work will not be transferred because of its intimate relationship to other mining technologies. (Emphasis supplied.)

In a report on Federal coal research, the General Accounting Office (GAO) noted that, until the Energy Reorganization Act of October 1974 when ERDA was created, "there had been no focal point for Federal coal research program efforts. The present program had evolved over a period of years in response to the specific missions of the primary coal research agencies, with each agency [Interior's

[33] "Energy Reorganization Act of 1973": Report of the House Committee on Government Operations, to accompany H.R. 11510: U.S. Cong., 93d, 1st sess., Rept. No. 93-707, Dec. 7, 1973, 73p.; quotation from p. 16.
[34] "Energy Reorganization Act of 1973." Hearings, Subcommittee of the House Committee on Government Operations, on H.R. 11510, Nov. 27-29, 1973: U.S. Cong., 93d, 1st sess., 1973, 422 pages (quotation from p. 93).
[35] Ibid., p. 94.

Bureau of Mines and Office of Coal Research, and the Environmental Protection Agency] pursuing its own research objectives, priorities, and goals." [36] (See tables 9–11.)

The GAO report admitted that the creation of Interior's Office of Research and Development in May 1973 had resulted in the establishment of a unified coal research program within the Department, intended to provide clear lines of research responsibilities between the Bureau and OCR. Also, the GAO report stated, the Office of Management and Budget in March 1974 had designated the Department of the Interior as the lead agency for developing a Governmentwide program-planning document for coal extraction and utilization and land reclamation. Despite these 2 years of efforts at coordination in Interior, GAO believed that "the establishment of ERDA should be a major step in . . . developing a unified coordinated Federal coal research program." [37]

Program effort during the 5-year period, 1970–74, is given in tables 9, 10, and 11, along with projected expenditures during the succeeding 5-year period, 1975–79.[38]

TABLE 9.—FEDERAL COAL RESEARCH EXPENDITURES, FISCAL YEARS 1970–74, BY AGENCY

[Dollar amounts in millions]

Agency	Amount	Percent
OCR	$223.7	48
BOM	170.0	37
EPA	60.5	13
Other	8.8	2
Total	463.0	100

Source: GAO, 1975, p. 23.

TABLE 10.—FEDERAL COAL SUPPLY RESEARCH, FISCAL YEARS 1970–74, AND PROJECTED 1975–79, BY PROGRAM

[Dollar amounts in millions]

Program	Fiscal years 1970–74		Fiscal years 1975–79	
	Amount	Percent	Amount	Percent
Mine health and safety	$108.6	89.5	?	?
Land reclamation	10.7	9.0	$325	100
Mining technology	1.5	1.5		
Total	120.8	100.0	325	100

Source: GAO, 1975, pp. 22, 30.

[36] GAO, Federal Coal Research—Status and Problems To Be Resolved: *General Accounting Office Rept RED–75–322*, Feb. 18, 1975, 95 pages (quotation from p. 31).

[37] Ibid.

[38] AEC "Integrated National Energy R. & D. Program." U.S. Atomic Energy Commission, December 1973.

TABLE 11.—FEDERAL COAL USE RESEARCH, FISCAL YEAR 1970–74 AND PROJECTED 1975–79, BY PROGRAM

[Dollar amounts in millions]

Program	Fiscal year 1970–74		Fiscal year 1975–79	
	Amount	Percent	Amount	Percent
Conversion to synthetic:				
Gas	$127.9	37.5	$540	29.0
Liquid	86.7	25.5	375	20.5
Synthetic fuels	0	0	355	19.0
Pollution abatement	64.7	19.0	260	14.0
Direct use in electric power generation	43.7	12.5	200	11.0
Support projects	18.7	5.5	120	6.5
Total	341.7	100.0	1,850	100.0

Source: GAO, 1975, pp. 22, 30.

This concern over coal research programs shown by the testimony at the 1973 hearings and the unclear wording of the House Report, has been continued in subsequent hearings in both Houses of the Congress as the delineation of Bureau of Mines and ERDA responsibilities in fossil fuel research were examined. For example, the different interpretations by the House Appropriations Committee's Subcommittee on Interior and by the House Science and Technology Committee of the mining research picture as applied to fossil fuels is given in the following exchange of correspondence, dealing with section 102 of H.R. 3474, an amendment to the ERDA authorization bill.

The House Appropriations Subcommittee had stated that H.R. 3474 "proposes to duplicate or supersede the present effective and ongoing (mining related energy) research so ably conducted by the Bureau of Mines." [39]

Mr. Teague, in response to a similar letter of April 16, 1975, from Interior Department Secretary Rogers C. B. Morton, replied that the general ERDA authority provided for that agency "to be involved with research and development for all aspects of the fuel cycle for fossil fuels," and that "Section 103 directs ERDA to exercise central responsibility for policy planning, coordination, support, and management of research and development programs respecting all energy sources." Mr. Teague continued that the House Committee on Government Operations (H. Rept. 93–707) "makes it clear (p. 18) that 'some' but not all of 'the mining technology-research activities' will remain in the Bureau of Mines." The issue centers on the Office of Coal Research, which was transferred in toto from the Interior Department to ERDA (Public Law 93–438), with the direction that "ERDA shall develop through research, new and more efficient methods of mining, preparing, and utilizing coal."

Interior Assistant Secretary Jack W. Carlson replied on August 20, 1975, to Mr. Teague's letter by agreeing that ERDA has broad authority in this area. However, both the House and Senate Government Operations Committees became aware, during consideration of the bill, that clarification of intent of the Act was needed to keep it from authorizing research and development work by ERDA which would duplicate work being done by the Bureau of Mines. Thus

[39] Letter from Subcommittee Chairman Sidney R. Yates and ranking minority member Joseph M. McDade to House Science and Technology Committee Chairman Olin B. Teague, Apr. 14, 1975.

clarifying language was added to each Committee's report, as follows (Assistant Secretary Carlson's letter, p. 1):

> Research on coal mining technology, including coal analysis and preparation, as well as the use of coal for metallurgical processes will be continued by the Bureau of Mines, especially as such research relates to mining and metallurgical technology or mine health and safety. . . . These include responsibility for mining metals and minerals, mine health and safety, mined area reclamation . . . (Senate Committee on Government Operations).
>
> Energy-related work which will remain in the Bureau includes some of the mining technology research activities. Expertise in these areas is essential for mining health and safety research and provides support required to avoid disruption of the Bureau's remaining program. This work will not be transferred because of its intimate relationship to other mining technologies. (House Committee on Government Operations)

Energy data collection and analysis

Another aspect of the possible duplication of effort between ERDA and the Bureau of Mines is in the area of data collection, analysis, and publication.

For many years the Bureau has had the responsibility for—

> * * * surveillance and evaluations of the industrial and commercial outlook for minerals and fuel deposits; studies to determine the relationships of mineral supply demand and technology to the national and world economy, . . . cllection, evaluation and publication of mineral industry statistics.[40]

ERDA, through Title I of the Energy Reorganization Act of 1974, has responsibilities that include both the dissemination of information resulting from its research and development program, and the developing, collecting, and distribution of scientific and technical information regarding energy-utilization techniques. In addition, ERDA had general authority to receive from other agencies, upon request, "any information or other data which the Administrator deems necessary . . ."[41]

The ERDA appropriations authorization bill, H.R. 3474 (which was signed by the President on December 31, 1975,[42] passed the House on June 20, 1975) gave authority to the ERDA Administrator to "establish, develop, acquire, and maintain a central source of information of all energy resources and technology—for research and development purposes."

Concern that the energy information programs of ERDA and the Bureau (and the Federal Energy Administration) would overlap or duplicate each other was expressed in the report of the House Appropriations Committee, as follows:

> The Department of the Interior has for many years been the Nation's principal source of energy and mineral resources information. The Federal Energy Administration is developing its own extensive data gathering and processing capability. The newly created Energy Research and Development Administration is moving to establish its own energy resources data bank. It is evident that the three closely associated and cooperating agencies are duplicating their data collecting efforts . . . .[43]

C. MESA, HEALTH AND SAFETY RESEARCH

The Bureau of Mines has been conducting research to solve problems of health and safety for miners, ever since its creation in 1910. Because of concern over the continued high incidence of injuries and

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[40] GSA, 1973, p. 271.
[41] Public Law 93-322, sec. 105(h):
[42] Public Law 94-187.
[43] "Department of the Interior and Related Agencies Appropriation bill, 1976" Report on H.R. 8773, July 18, 1975; U.S. Congress, 94th, 1st sess., H. Rept. 94-374, 103 p. (quotation from p. 7).

fatalities in the mines, the Secretary of the Interior in 1973 separated the mining regulatory function from the mining research function, by creating the Mining Enforcement and Safety Administration.[44]

MESA has responsibility for:

1. Enforcing coal-mine and metal and nonmetal mining health and safety regulations;
2. Assessing penalties for violations of mine health and safety laws;
3. Education and training in mine health and safety; and
4. Developing mandatory health and safety standards.

Responsibility for the mining research, development, and demonstration function continues to reside in the Bureau of Mines.

There must be close communication between the two agencies, MESA and the Bureau of Mines, so that the needs identified by the former are adequately addressed by the latter in its research, and so that the technologic solutions discovered by the latter are completely transferred to the former for their implementation.

In late 1974 and early 1975 it became apparent that this separation of function and communication between the two agencies was not succeeding too well, which occasioned Jack Carlson, Interior Assistant Secretary for Energy and Minerals, to send a memo to the directors of the two agencies on June 26, 1975. Carlson's memo left management of the research in the hands of the Bureau, but gave greater control over the establishment of priorities for some of the program to MESA. Specifically, the memo provided that:

> * * * no less than 10 percent of health and safety research funds will be selected at the sole discretion of MESA, and until that level is achieved, one-fourth of the funds available for new projects shall be designated by MESA.[45]

A further specification was that no less than $2 million should be so designated by MESA in any fiscal year. To assure that the agencies would adhere to the policy, Carlson ordered the formation of an ad hoc task force to set priorities for new research projects—this task force to consist of two representatives each from MESA and the Bureau, and one representative from either the Office of Minerals Policy Development or the Office of Research and Development in Interior.

Apparently this agreement did not immediately solve the matter because 2 months later the coal industry expressed its annoyance over "bureaucratic infighting and government inertia." [46] The flareup occurred at the opening session of the Sixth Annual Institute on Coal Mining Health and Safety Research at Virginia Polytechnic Institute, in August 1975. Carl Bagge, president of the National Coal Association, said:

> Engineers working on research contracts for new coal production machines for the U.S. Bureau of Mines report long-running frustrations in trying to get new designs approved by MESA [a sister] Department of the Interior Agency which must OK all such equipment.[47]

Bagge's comments were agreed to by Karl Kafton, a West Virginia member of the United Mine Workers' international executive board, who also urged an end to the feuding between the two agencies.

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[44] Secretarial order, May 7, 1973.
[45] "Interior's Safety Research Scrap Settled": Coal Week, July 14, 1975.
[46] Steele, H. Edward, "Conflict Flares at Institute Meeting"; Coal Mining & Processing, November 1975 pp. 60, 65-67.

The two agencies were defended by Interior Assistant Secretary Carlson, who noted that most of the differences between MESA and the Bureau were being resolved, with research and development being assigned to the latter.

During 1975, the Interior Assistant Secretary for Energy and Minerals determined that management and conduct of the health and safety research should remain in the Bureau of Mines but with procedures established to strengthen MESA participation in the program and with a formalized methodology for joint evaluation of ongoing and proposed applied research projects as a prerequisite to their inclusion in each future year's program.

A joint Department/BOM/MESA task force developed the procedural mechanisms and evaluation criteria which both bureaus are following in formulating the fiscal year 1977 program. Briefly, the steps are: (1) a canvass of both organizations for research needs and proposals to be submitted in a standard written format; (2) referral of the combined array of proposals, including any received from outside sources, to subprogram evaluation teams having equal representation from MESA and BOM who rate and rank projects using agreed-upon criteria and methodology; (3) formulation of the program by matching funds allocated to subprogram areas with the cumulative costs of the rank-ordered proposals received from the evaluation teams.

To define both the overall program budget request, subprogram allocations and proportionate amounts for basic and applied research, the Bureau and MESA will collaborate on a "strategy" paper which outlines the goals and priorities for health and safety research—both short- and long-range. This will both serve as a better guide to future program budget requests, and will serve as a basis for objective evaluation of program results.

A memorandum of understanding covering the interface obligations of both agencies was signed by the Bureau Director and the MESA Administrator on February 6, 1976. There have been many additional constructive interactions than just the development and agreement on the memorandum of understanding, as follows:

The Bureau in fiscal year 1976 has made major efforts to assist MESA in its development of new and revised standards, and established committees to which MESA can turn for specific assistance. MESA is using Bureau researchers in its current drive to update and revise all standards for approving equipment, materials, and systems for use in mining, because it is essential that all MESA standards reflect the newest technologic developments which have been demonstrated to be practical and achieveable.

Another significant example of constructive interaction is the correlation of Bureau technology-transfer meetings with MESA and industry needs. Public Law 91–173 requires the promulgation of standards to illuminate working places in underground coal mines. The Bureau held three public meetings to describe research-developed lighting systems in support of MESA's recommendation for promulagtion of standards. Similarly, the Bureau participated in a recent MESA-sponsored seminar on the solution of potential health and safety problems in oil shale mining.

The Bureau has responded to research needs that MESA has identified as urgent but which were not part of the original programs planned and approved by the Bureau. Important examples are: (1) Bureau/MESA cost-sharing of an environmental health survey of underground metal and nonmetal mines; (2) research to find alternates to unsafe blasting practice used in Florida limestone mines; and (3) fire-simulation tests to investigate factors important to the catastrophic spread of mine fires such as at the Sunshine Mine in Idaho a few years ago.

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[47] Steele, 1975, p. 60.

MESA has reciprocated in many important ways, as follows:

The Bureau's major research to advance coal mining technology requires cooperative MESA work to set the conditions for safe mine trials. For example, MESA has put major effort into three important Bureau energy projects:

Use of a tunnel-boring machine to allow rapid mine development in deep gassy coal seams.

Combining cutting and bolting cycles into one machine to increase productivity.

Criteria for safely piping methane extracted from drainage holes within the mine to the surface for commercial use.

The focus of most issues between the Bureau and MESA was the MESA program element entitled Technical Support, whose funds aggregated only one-third as much as those of the Bureau of Mines (see table 12). The purpose of MESA's Technical Support activities is "to provide expert technical and engineering assistance and information necessary for the * * * administration of MESA's responsibilities," [48] and to provide engineering and scientific consultation for the Bureau of Mines in developing their health and safety research program. These technical support activities involve "the development and evaluation of new health and safety engineering technology."

TABLE 12.—FUNDS FOR MESA'S TECHNICAL SUPPORT AND FOR BUREAU OF MINES' MINING RESEARCH RELATED TO HEALTH AND SAFETY, FISCAL YEARS 1975 AND 1976

[In millions of dollars]

	Fiscal year 1975		Fiscal year 1976	
	MESA	BOM	MESA	BOM
Coal mining	$6.8	$27.6	$8.0	$29.2
Metal and nonmetal	2.8	4.6	4.1	5.7
Total	9.6	32.2	12.1	34.9

Source: USDI press release (adapted from E/MJ, March 1975, p. 40).

During the recent hearings of the House Science and Technology's Subcommittee on Fossil Fuels (February 11, 1976) the resolution of the MESA-Bureau conflict was described in detail by the following witnesses:

Dr. William Fisher, Acting Assistant Secretary for Energy and Minerals;

Dr. Thomas V. Falkie, Director, Bureau of Mines; and

Robert Barrett, Administrator, Mining Enforcement and Safety Administration.

Dr. Fisher supplied the subcommittee with a copy of a Memorandum of Understanding of February 6, 1976, which spells out these areas of mutual concern and activity by the two bureaus. (See Appendix VII.)

Both Dr. Falkie and Mr. Barrett assured the subcommittee that the matter had been resolved, and that the two bureaus would be operating in a coordinated and mutually supportive manner with regard to mine health and safety research.

[48] MESA, *Budget Justification, fiscal year 1976*, pp. 27-28.

D. MINERAL STATISTICS

General

The Bureau of Mines has published since 1932–33 an annual *Minerals Yearbook*, and in more recent years a set of periodical (weekly, monthly, quarterly, and annual) statistical surveys called *Mineral Industry Surveys*. In addition, since 1955, it has published a 5-year compendium of information on specific mineral commodities, entitled *Mineral Facts and Problems*. (See Appendix VIII.)

Through these publications, the Bureau has been considered the principal source of most of the significant data on U.S. production, trade, and use of mineral resources, with attention being paid also to the international scene in the past 15 years or so. Bureau data were the basis for many parts of the Paley Commission Report of 1952,[49] for the National Commission on Materials Policy Report of 1973,[50] and for the annual reports of the Secretary of the Interior as required by the Mining and Materials Policy Act of 1970.

The surveys and investigations staff of the House Committee on Appropriations recently acknowledged the value of the Bureau's data gathering and analysis program, in a report on Federal Energy Data Collection Activities and Systems (March 1976), as follows:

> The BM has been widely praised as having one of the best systems of gathering, analyzing and publishing meaningful data that exists in the Federal Government. BM has assembled a wide range of commodity class experts and has established a well-known data processing operation in its Denver ADP computer center. Moreover, BM sells computer tapes to both Federal and private sectors which are used in long-range planning and forecasting models. (p. 95.)

However, despite the usefulness of these sources of information, they have possessed serious flaws which have limited their usefulness and have resulted in adverse criticism of the Bureau of Mines' effort. Partly this criticism has focused on the lack of analysis, partly on the inadequacy of coverage, but mainly the criticism has been directed at the lack of timeliness in the publication of the data.

As a result, the Bureau has introduced a couple of new publications which present analyses of data for selected commodities, it has expanded its coverage especially in the international area, and it has attempted to speed up the publication schedule, as will be discussed in detail in the following paragraphs.

In addition, the Bureau publishes three monthly international publications, dealing with coal (*International Coal Trade*), petroleum (*International Petroleum Annual*), and other minerals (*Mineral Trade Notes*). All three contain statistical data, and the latter contains news notes of happenings in specific countries.

Timeliness

Only volumes I and III of the three volumes of the 1973 Minerals Yearbook had been published by the Government Printing Office (GPO) as of this writing (August 15, 1976), a delay of more than 2 years.[51]

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[49] President's Materials Policy [Paley] Commission, "Resources for Freedom:" U.S. Cong. 82d, 2d sess., Doc. 527, July 2, 1952, 5 vols.

[50] National Commission on Materials Policy, "Material Needs and the Environment, Today and Tomorrow," June 1973. (Reprinted, July 15, 1974, as U.S. Cong., 93d, 2d sess., S. Doc. 93–97.)

[51] This publication record was worse during the 1950's when it took 3 years to get the volumes published. From 1959 to 1964 the lag was only 1 year, but since then it has been 2 years except for 1972 (3 years) and 1973 (2 years for vol. I; 3 years for vol. II, and more for vol. III).

Preprints of individual chapters, however, are made available separately as they come off the press. But this is only a mixed blessing, because of the unpredictable dates when they appear and because they are still 10 to 20 months out of date.[52]

Why should this be? The Bureau of Mines says that it is caused by two factors: (1) The need to verify the statistics that have been collected—which usually takes as much as several months, and (2) delays in the GPO.

Actually, preliminary statistics are available for most commodities within a month after the end of the year, in the form of Bureau-distributed single-page *Mineral Industry Surveys* which present summary tables and a brief explanation. These summary pages are later updated and expanded—but that does not occur for 7 to 12 months, which is not significantly in advance of the more complete treatment in the preprint chapters of volume I of the Minerals Yearbook.

These January sheets are also available for volume II (States) but not for volume III (International). The latter volume is not available until 2 or 3 years after the end of the year to which its statistics pertain. The individual preprint chapters of volumes II and III are very sporadic in their appearance, so the user gets little satisfaction in attempting to accumulate a usable set much in advance of the publication of the full volume.[53]

Such a record of lack of availability of data restricts the usefulness of the *Minerals Yearbook* to that of a not-too-recent historical record. For the numerous current problems of minerals policy which demand up-to-date statistical information, it is clear that a better means must be devised for gathering the data, verifying them, and getting them published in a timely manner by GPO or otherwise making them available.

Another source of data by the Bureau is presented in *Minerals & Materials; A Monthly Survey*, which has been issued since November 1974. This publication has settled into a format of presenting updated charts and tables for a dozen mineral commodities, which cover production, consumption, exports, imports, and prices. In addition, a page of recent highlights in the mineral field is given, and an essay on a mineral subject was included in the first six issues.

As will be mentioned in the following section, the Bureau has begun publishing *Commodity Data Summaries*, an annual compendium of a two-page synthesis of each mineral commodity, which deals with supply, demand, uses, U.S. Government programs, exports, imports, and reserves.

These annual *Commodity Data Summaries* of the Bureau of Mines constitute an up-to-date and ready reference to mineral commodities. In contrast to the delayed publication problems of the Bureau of Mines regarding the other mineral data series, just discussed, this information on mineral statistics for the calendar year is made available within 1 month after the end of that year. The annual *Commodity*

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[52] For example, of the 77 chapters in volume I for 1973 (which deals with individual mineral commodities), less than 20% had been published within 12 months after the end of that year, less than 65% had been published within 15 months, and only 80% had been published within 18 months. In fact, it took 20 months to publish all 77 preprint chapters.

[53] For example, the 1973 preprints of volume II were received as follows: none within 12 months; less than 15% within 18 months, and only half of them within 2 years. Volume III had a better record, but one that fell short of the dismal record of volume I, because no preprints of volume III had been published within 12 months, 40% within 18 months, and 91% within 2 years.

Data Summaries therefore is an extremely useful and timely reference volume, although its statistics are preliminary.

Analysis

The Bureau has published four issues of *Mineral Facts and Problems*, a tremendous compendium of information on 88 mineral commodities arranged under four general categories: energy resources, ferrous (iron-related) minerals, nonferrous minerals, and nonmetallic minerals. Four issues have been published and the fifth is nearly complete [54] with all separate preprint chapters published by the end of August, 1976.

The Bureau claims that *Mineral Facts and Problems* is a "stimulating planning document." [55] The publication does present an introductory basis for policy decisions, and the 1970 and 1975 editions in particular have emphasized future outlook. Although in the discussion of each commodity an identification of problems is made, recommended policy actions are not given. A chapter outline is given in Table 13, herein.

TABLE 13. CHAPTER OUTLINE FOR MINERAL FACTS AND PROBLEMS, 1975 EDITION

I. [General introductory statement.]
II. Background:
    Industry pattern.
    Technology.
        Definition of terms, grades, and specifications.
        Current technology.
        Research.
    Apparent reserves.
    Supply-demand relationships:
        Production, consumption, and trade.
        Conservation.
    Byproduct-coproduct relationships.
    Consumption patterns.
        Uses.
        Alternate materials.
    Economic factors:
        Prices and costs.
        Employment and productivity.
        Transportation.
    Taxes and traffic.
        Government programs.
        Strategic considerations.
    Environmental considerations.
III. Outlook:
    Demand [several sectors].
    Future supply-demand relationships.
    Possible advances in technology.
IV. Problems.
V. References.

As mentioned in the preceding section on "Timeliness," each of the first six issues of the new Bureau publication *Minerals & Materials: A Monthly Survey* did present an essay on a mineral subject, which usually had policy overtones. A listing of those essays, in the last half of calendar 1975, is given below:

July—Carlson, Jack W., "Minerals and Materials Information Collection and Analysis in the Department of Interior—A Systems Approach," p. 1–11.

[54] Bulletin 556 in 1956; 585 in 1960; 630 in 1965; 650 in 1970; and 667 in 1975 [1976].
[55] USBM, "Mineral Facts and Problems, 1970 Edition": U.S. Bureau of Mines Bull. 650, p. III.

August—Falkie, Thomas V., "The Importance of Coal in Achieving Energy Independence," p. 1–12.
September—McKelvey, V. E., "Energy, Minerals, and Growth," p. 1–15.
October—Anon., "Availability of Minerals Data," p. 1–2.
November—Wang, K. P.; "The People's Republic of China; A New Industrial Power with a Strong Mineral Base," p. 1–22.
December—Kleppe, Thomas S.; 41st Secretary of the Interior, p. 1.

The other major source of mineral policy analysis, mentioned above, to which the Bureau contributes is the *Annual Report of the Secretary of the Interior under the Mining and Minerals Policy Act of 1970*. This annual report series began with two that discussed policy issues, the first and second, in 1972 and 1973, with 42 and 73 pages, respectively.

The first of these annual reports was notable (1) in identifying critical policy matters and (2) in its lack of organization and its redundancy. The second was more refined and had better illustrations, but presented essentially the same policy issues. The third annual report, in 1974, was never issued, and the fourth in 1975 consisted of 63 pages that looked like the 1973 report.[56]

Each year there has been an appendix of commodity data,[57] supplied by the Bureau of Mines. Totaling 346 pages in 1972 and 572 pages in 1973, these were published as part of the annual report set. In 1974 the Commodity Data Summary Appendix had been trimmed to 193 pages but it had lost its companion, the policy document, as noted above. In 1975 the Bureau of Mines' *Commodity Data Summaries* (193 pages again) volume was published separately, with no reference to the policy document; the latter was not issued by the Secretary until May of 1975.

E. FEDERAL SURFACE MINE REGULATION COSTS

Introduction.—President Gerald Ford vetoed on May 20, 1975 a surface-mine regulation bill because of the excessive losses which he claimed would be caused by its implementation—reduced coal production of as much as 162 million tons by 1977, and as many as 36,000 people put out of jobs.

Different views of the costs were presented by executive agencies (including the Bureau of Mines), and the congressional debate of the previous 6 years continued in the ensuing couple of weeks while the Congress prepared to vote to override the President's veto.

The veto was not overridden by the Congress—so, after 6 years of concerted effort to get a Federal law to regulate strip mining and reclamation, it was not yet accomplished.

The bill.—At the end of the 93d Congress the House and Senate had passed legislation (S. 425) that would have regulated surface coal mining. That bill, and its House counterpart (H.R. 3) had been the subject of extensive hearings in both Houses of the Congress, and had been the outgrowth of earlier legislation that was considered

[56] And the recommendations of the 1973 Report of the National Commission on Materials Policy, also.
[57] The annual commodity data summaries originated as early as 1957, as a means of informing the Congress about pertinent mineral data for the year just completed; the summaries have appeared in time for the beginning of each session of the Congress since then. (Paul Meadows, Bureau of Mines, personal communication, June 23, 1976.)

by both the 91st and 92d Congresses. The President did not sign S. 425 in December, and it expired with the end of the 93d Congress.

On February 6, 1975 the President noted [58] that S. 425 of the 93d Congress had been reintroduced in the 94th Congress (S. 7 and H.R. 25), offered an administration bill as a substitute, and opposed S. 425 because it would have:

(1) Caused excessive coal-production losses, including losses that are not necessary to achieve reasonable environmental protection and reclamation requirements. The Federal Energy Administration estimated that the bill, during its first full year of operation would reduce coal production between 48 and 141 million tons, or approximately 6 to 18 percent of the expected production. Additional losses could result which cannot be quantified because of ambiguities in the bill. . . .

(2) Caused inflationary impacts because of increased coal costs and Federal expenditures for Federal activities which, however desirable, are not necessary at this time.

(3) Failed to correct other deficiencies that had been pointed out in executive branch communications. . . .

Regarding No. 1, the President recalled the recent energy crisis and pointed out that "losses of coal production are particularly important because each lost ton of coal can mean importing four additional barrels of foreign oil." The administration bill, he noted, would permit the Nation to achieve the goal of doubling the coal production by 1985—including the opening of 250 major new coal mines ("the majority of which must be surface mines") and the construction of approximately 150 new coal-fired electric generating plants—and still meet "reasonable environmental protection standards."

On February 19, 1975 the administration was invited to present its views on H.R. 25 before the House Interior and Insular Affairs Committee. Interior Secretary Rogers Morton quoted from the President's State of the Union address of the preceding month, wherein the President noted his proposed bills to the Congress which would (1) increase supplies of petroleum and alternate energy sources (especially coal), (2) reduce demand for energy, and (3) increase U.S. capacity to meet supply disruptions on an emergency basis. Noting that "surface mining legislation must . . . strike an appropriate balance between the need to develop our coal resources and to guarantee sound environmental safeguards," he mentioned the President's proposed 27 changes from the vetoed bill (S. 425), of which eight, Morton said, are of critical importance.

Morton referred [58a] to the FEA estimate of 48–141 million tons of lost production in the first year of complete implementation of that bill, and stated that this loss would be cut by one-third or more (to a loss of 33–80 million tons) under the President's proposed bill—thus holding "production losses within acceptable limits while at the same time providing reasonably needed protection of land and environmental values."

Administration's credibility challenged.—On February 19, 1975, Congressman Udall charged [59] that "either their [the Administration's] data are phony and the Administration doesn't believe its own pro-

[58] President Ford, letter to the Speaker of the House, Feb. 6, 1975.
[58a] Transcript, hearings on H. R. 25, House Committee on Interior and Insular Affairs, Feb. 18, 1975, p. 15.
[59] Press release.

jections or somebody in the Department has been extremely negligent in drafting the Administration's bill." He continued:

> Estimated production loss figures advanced by the Administration have varied widely, even though they are all presumably based on the original analysis completed by the Department of the Interior last May. . . .
>
> Original estimates by the Department range from 31 to 187 million tons per year. Last November [1974], however, Secretary Morton stated that enactment of the Conference Report would result in a loss of 14 to 38 million tons per year.
>
> Now . . . the President said that the same bill that existed on November 19—except for the surface owner consent provision—would result in a loss of 48 to 141 million tons. . . . Presumably this increase is not due to the limited surface owner consent provision of H.R. 25, since the administration does not list amendment of that consent section as high priority. (Indeed, none of the 'critical' changes sought by the President are reflected in the quantified production loss tables contained in the Department's study)."

A presentation similar to Morton's was made by Interior Assistant Secretary Jack Carlson [60] on February 20, 1975, before the Senate Interior and Insular Affairs Committee, in which Carlson used the same numbers. The loss in coal production would result in a loss of 46,980 jobs (26,100 mining jobs and 20,880 jobs in associated industries). The 48 to 141 million tons of production loss would come from:

	Millions
Small mines	22 to 52
Steep slope mining, siltation, aquifers	15 to 68
Other (including alluvial valley floors)	11 to 21
Total	48 to 141

The numbers are changed.—In late April 1975 Federal Energy Administrator Frank Zarb wrote [61] to the House and Senate conferees, telling them that the coal production losses would be 50 to 162 million tons under S. 7, or 62 to 162 million under H.R. 25. Furthermore, he said, 10,000 to 36,000 jobs would be lost. In addition, consumers would have to pay the following financial costs:

	Millions
Coal taxes	$130 to $204
Production and reclamation	171
Federal and State enforcement	100 to 160

And finally, according to Zarb, the long-term effect on coal mined would be to deny 53 percent of the Nation's 137 billion tons of surface mineable coal reserves from ever being recovered.

Presidential veto.—On May 20, 1975, the President vetoed H.R. 25, because: [62]

1. As many as 36,000 people would lose jobs.
2. Consumers would pay higher costs particularly for electric bills.
3. The Nation would be more dependent on foreign oil.
4. Coal production would be unnecessarily reduced.

[A loss of 40 to 162 million tons in 1977.]

Senator Metcalf answered [63] these objections saying, with regard to No. 1, that in February, Interior Secretary Morton had told the House Interior Committee that "enactment of surface mining legislation would result in a net gain of employment." Regarding No. 4, losses of

[60] "Surface Mine Briefing", Senate Committee on Interior and Insular Affairs, Feb. 20, 1975; Briefing, 94th Cong., 1st Sess., pp. 172–232 (esp. pp. 208–209).
[61] As reported in *Coal News*, Apr. 25, 1975, pp. 1–2.
[62] "Veto of the Surface Mining Control and Reclamation Act of 1975," message from the President of the United States vetoing H.R. 25: 94th Cong., 1st sess., H. Doc. 94–160, May 20, 1975, pp. III–IV.
[63] "Metcalf Urges Senate to Override Strip Mining Veto," Congressional Record, May 20, 1975, p. S. 8812.

coal production amounting to 140 [sic] to 162 million tons in 1977, "these estimates have never been explained by the Federal Energy Administration or the Interior Department. They have not identified which provisions of the bill cause the problem or why the reclamation standards could not be met."

The numbers again.—In a press conference on May 19, 1975, FEA Administrator Zarb had repeated [64] the Administration's contention that 40 to 162 million tons of coal production would be lost annually, but admitted that "the loss was difficult to estimate because of many vague provisions in the bill." Zarb also repeated the unemployment number, by saying that "it is our calculation that up to 36,000 people can be put out of work in the first year."

Editorial comment in the Nation's press largely supported the Congress in its attempts to override the President's veto, one editorial stating [65] that the administration numbers should be discounted because the bill's supporters have argued that:

1. Coal production, which already exceeds market demand by 10 percent, would not lag because the Government already has leased rights to 15.5 billion tons of coal;
2. Jobs would actually increase because of reclamation provisions of the bill;
3. Production costs would increase no more than 10 percent, if that;
4. Coal price increases have been following, not preceding, oil price increases; and
5. Although some coal in the vast reserves of the West would be locked up, it would not be sufficient to harm the Nation's effort to become energy self-sufficient.

The Congress seeks answers.—In an attempt to get at the bottom of the conflicting numbers' matter, the Congress took the unusual step of inviting the Administration to justify its veto of the surface mining bill, in a briefing on June 3, 1975. The hearing was held jointly by two subcommittees of the House Interior and Insular Affairs Committee—the Subcommittee on Energy and the Environment, and the Subcommittee on Mines and Mining—and the Senate Interior Committee's Subcommittee on Minerals, Materials, and Fuels. FEA Administrator Zarb noted [66] that the Administration's loss estimates were conservative ones, because they related only to impacts on steep slopes, aquifers, siltation, and alluvial valley floors. Thus, he said, "Our estimates of 40 to 162 million tons of coal attributable to H.R. 25 are not all-inclusive," as they have not attempted to quantify other adverse impacts of the bill such as: (1) the impact on coal miners' health and safety; (2) implementation of enforcement of provisions such as (*a*) designation of areas unsuitable for mining, (*b*) surface owner's consent, and (*c*) State control over federally owned coal; and (3) losses resulting from litigation "necessary to resolve ambiguous features of the bill and its legislative history."

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[64] "Strip Mining": Congressional Quarterly Weekly Report, May 24, 1975, p. 1065.
[65] "Strip Mining: The Evidence Is There," Los Angeles Times, May 21, 1975, pt. 2, p. 6.
[66] Prepared statement on H.R. 25; in "Surface Mining Veto Justification Briefing," Hearing, Interior and Insular Affairs Committee, June 3, 1975: U.S. Cong., 94th, 1st sess., House serial No. 94-23, p. 12-18.

Zarb continued with a summary of the details as spelled out in Bureau of Mines' Director Thomas Falkie's analysis,[67] submitted on May 23, 1975, to the Senate Subcommittee, as follows:

> The low range of our estimates represent the adverse impacts we expect if the bill were interpreted loosely, [and] the high range of estimates represents those losses that we would expect if a strict, liberal interpretation and vigorous implementation were given to each provision * * *.
>
> We have estimated that from 40 to 162 million tons of annual coal production would be lost during the first full year of implementation. Losses would occur in three general categories:
>
> (1) Reduced production or closure of small mines;
>
> (2) Delays or prohibitions arising from the steep slope, siltation, and aquifer protection provisions and, most important perhaps;
>
> (3) Bans on mining operations which would affect alluvial valley floors.

Regarding No. 1, Zarb's statement noted that many such mines would be forced to close for economic reasons, with the estimate that "at least 40 percent and possibly all of projected production from small mines would be precluded under H.R. 25." These losses are not included, however, in the 40 to 162 million tons.

Regarding No. 2, Zarb estimated losses ranging from 7 to 44 million tons in the first full year of implementation, stating further that strict interpretation and application of the steep-slope provisions alone "would result in loss of production from virtually every mine operation on slopes in excess of 20 degrees—loss totaling from 7 to 25 million tons." The siltation provision is unrealistic, Zarb reported,[68] because it would require operators to apply technology that is prohibitively expensive in order to prevent "even relatively insignificant siltation."

Regarding No. 3, Zarb estimated a loss of 11 to 66 million tons of coal production during the first full year of implementation. Further, he he said, the long-term effect would be 1,000 times greater—a loss of 17 to 66 billion tons of coal, which would be permanently locked in the ground.

Turning to the unemployment issue, Zarb stated[69] that, based on the loss of 36 tons per day per miner,

> Direct job losses could affect between 5,000 and 20,000 coal miners; and for each 10 miners' jobs lost, a minimum of an additional 8 jobs would be lost in other sectors of the economy dependent upon the mining industry. Applying this factor to projected production losses and manpower efficiency rates applicable to such losses, we have concluded that from 9,000 to 36,000 jobs would, in fact, be lost as a result of implementation of H.R. 25.

The backup document by Bureau of Mines' Director Falkie is reproduced in its entirety herein—as Appendix IX.

Criticism of the Bureau of Mines.—During the hearing on June 3, 1975, Bureau Director Falkie was asked penetrating questions on how the loss numbers were derived, and Subcommittee Chairwoman Mink asked for additional submittals in writing. This produced an exchange of correspondence that showed the Subcommittee's dissatisfaction and distrust concerning the Bureau's methodology and analysis and with its tardiness in supplying the information.

On June 4, 1975, Dr. Falkie's letter [70] to Mrs. Mink provided infor-

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[67] Submission by Dr. Falkie during hearing on June 3, 1975; ibid, p. 133–142.
[68] *Ibid.*, p. 16.
[69] Ibid., p. 17.
[70] Ibid., p. 150–151.

mation on the impact of H.R. 25 small coal mines in the eastern United States. On June 5, Mrs. Mink's reply [71] took note of the incomplete and unsatisfactory nature of Falkie's letter, which answered only parts of two of the three questions asked, and did not answer the third at all. She observed, "One is led to wonder if some of this research, to provide answers to her questions, is being done after the fact, or is nonexistent." Dr. Falkie's subsequent letter of June 17 [72] provided the rest of the information requested on June 4.

Not satisfied with Dr. Falkie's documentation, Mrs. Mink wrote him [73] again, on June 26:

> You have not yet produced what I would regard as an objective economic analysis completed prior to the President's veto of H.R. 25 * * *. By your own admission, your breakdown of permit application requirement costs and your case history were both completed after the hearing * * *.
>
> More to the point * * * [you have not] presented a picture of the cost flow situation of small mines; you have not shown how costs of permit requirements of H.R. 25 would compare with other costs of the operator; nor have you shown based on their data, how the permit application costs would prove to be insupportable for the operator of the small mine * * *. This is the type of analysis which should have been carried out in advance of the President's veto * * *. If you expect the President's coal production loss figures attributed to the effect of the bill on small mines to be taken seriously * * *. This type of analysis is essential. In the absence of a respectable analysis; how can you possibly verify loss figures for small Appalachian mines * * *?

Furthermore, Mrs. Mink stated:

> We have Dr. William Miernyk of the Regional Research Institute in West Virginia, adamantly maintaining that the bill will have no significant coal production loss or job loss impacts in West Virginia, where according to your own estimates, small mine and steep-slope losses would be severe.
>
> To disprove these and other authorities who support the need for enacting H.R. 25, it is imperative that the Bureau of Mines reveal reliable, well-delineated, and completely researched economic studies which were completed as the basis for the President's coal production loss estimates * * *. I have seen not a shred of evidence that any such studies exist.

Dr. Falkie attempted to answer these questions and comments in his reply of July 11, 1975,[74] as follows:

> With regard to the detailed economic analysis of small mines to which you refer, it should be recognized that in 1973 there were over 2,000 small mines in Appalachia producing 50,000 tons of coal or less [per year] * * *, at an average of about 20,000 tons per mine. A detailed economic analysis of each of these mines' financial ability to absorb the additional costs (especially front-end costs) would have meant the examination of the financial situation of every one of these mines.
>
> This information would have been difficult to acquire because of its extensive and sensitive nature * * * [so] a selected sample of the small mine sector was issued instead. Based on this sample, the information available to us from many sources, and the experience of many engineers in the Bureau of Mines and the Federal Energy Administration, an engineering estimate was made.

Dr. Falkie's reply stressed the fact that, in a situation where the economics of a mining operation is a critical factor, it is often impossible to obtain the hard numbers that one would like to have in order to verify one's model, so extrapolations based on engineering assumptions and available data are the best tool available to the mining

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[71] Ibid., p. 150.
[72] Ibid., p. 152–154.
[73] Ibid., p. 155–156.
[74] Ibid., p. 156–157.

expert. He remarked, further, that one should keep in mind the fact that:

The immediate economic impact was only one factor used in determining the production impact on the small mines. Other factors which were considered included:

(1) Ability to obtain hydrologic information and control any hydrologic impact;

(2) Lack of technical expertise readily available for deriving the various application data;

(3) Shortage of drilling equipment;

(4) Additional equipment required to handle overburden because of the no spoil on the down-slope restriction;

(5) Complete removal of the highwall;

(6) Control of siltation; and

(7) Retainage [sic] of a portion of the bonding for at least 5 years after last year of vegetation.

Dr. Falkie also responded to the reference to Dr. Mierynk's work, by noting that the latter's analyses—

are based on the assumption that underground mines could absorb any losses. We have repeatedly stated our belief that this is not possible during the first full year of implementation because of the long leadtimes, from 4 to 7 years, needed for expanding existing operations and opening new mines to accelerate underground production.

The Senate staff analysis of the Administration's justification of the veto of H.R. 25 [75] presented a penetrating attack on the incompleteness and erroneous nature of some of the Administration's numbers and how they were derived. The staff analysis noted that:

The Administration refuses to assume that the coal industry can adjust by the first full year of implementation (1978), despite a 3-year phase-in period [76] and the vast extent of U.S. coal reserves. This assumption runs counter to Administration testimony that small mines go in and out of production * * * rapidly * * *, [and it] ignores the fact that there is considerable surge capacity within the industry.

Furthermore, the Senate staff report remarked that all losses feared by the Administration were for only a 3- or 4-year period beginning in 1978. In addition, charged the staff report, the Administration did not indicate in its methodology any netting out of production losses that overlap—as between small mines and steep slope mines.

And finally, the Senate staff report took the Administration to task for claiming that the enactment of H.R. 25 could result in the loss of 9,000 to 36,000 jobs. The Administration witnesses said that a substantial portion of this estimate was based on studies done by West Virginia University's Dr. Miernyk; however, the Senate staff report noted emphatically, Dr. Miernyk has stated that H.R. 25, "will not lead to any loss of jobs whatsoever."

The foregoing is merely the summary of the staff report; its full text is provided herein as Appendix (X), wherein the many specific and detailed charges are made, which it felt the Administration had left unanswered.

In addition to the foregoing exchanges between the House and Senate committees and the Administration on this bill, a number of Senators and Members of the House inserted in the *Congressional Record* further critiques of specific elements of the issue relating to the President's veto, as follows:

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[75] *Ibid.*, p. 158–167.

[76] The Administration, however, testified that there is a 7–8 year leadtime to put a new large surface mine into production.

Congressman John Melcher (June 6, p. H5064–H5065) criticized the Administration's alluvial valley losses because of testimony extracted from U.S. Geological Survey geologist R. F. Hadley. Hadley stated, in response to questions from Congressman Melcher, that three of the mines included on the Administration's list of nine Western mines which it said would have to close down, were actually not located on alluvial valley floors at all. Melcher stated that only two of those nine are on alluvial valley floors, and concluded that "the misrepresentations of fact behind the veto message indicate to me that the President desperately needs to shake up his staff." [77]

Congressman Philip Ruppe (June 6, p. E2907) inserted an article from the *Charleston (W. Va.) Gazette* for June 5, which quoted Dr. Miernyk as saying that his study had been improperly used by the Administration in supporting its charges that H.R. 25 would cost the jobs of possibly 36,000 workers.

Congresswoman Patsy Mink (June 6, p. E2934–E2935) cited the experience in West Virginia with a stricter State surface mining law, which, Dr. Miernyk says, has had virtually no adverse effect on jobs in the State. Similarly, she reported that in Pennsylvania the State Joint Legislative Air and Water Pollution Control and Conservation Committee pointed out that stringent regulation of surface mining in that State has boosted production there. Dr. Miernyk noted, she related, that in Ohio, where some marginal mines were forced to shut down after the State law was strengthened, there was no significant drop in either jobs or production, overall.

Senator Henry Jackson (June 6, p. S10031–S10032) commented that the Administration's production loss estimates are based on "highly unlikely and admittedly unrealistic interpretations of H.R. 25," and that all other estimates, costs, job losses, and oil imports are "based on these faulty production loshs estimates. In addition to citing other points that were also made in the Senate staff report on the veto (see above), he noted that althoug" the Administration denies that additional jobs will be created by the reclamation requirements of H.R. 25, its additional reclamation cost of $1 per ton, "largely represents additional labor cost and thus thousands of jobs."

After the Post-Veto Hearing—The *New York Times* reported on June 8, 1975 [78] that the Environmental Protection Agency had just received the results of an independent study of the impact of H.R. 25 on coal production, which disclosed that the production loss would be only half that estimated by the Administration's FEA, Interior, and Commerce Departments. The study, said the *Times*, had found omissions, distortions, and double-counting in the Interior Department-FEA forecast. In addition, the *Times* article cited another report, by a private consulting firm known as the National Economic

[77] Raymond Peck, Counsel for the Commerce Department, told the members of the Joint Committee that "there is confusion over what an alluvial valley floor is and what this bill prohibits (*Congressional Quarterly Weekly Report*, June 7, 1975, p. 1176).

[78] Article by Ben A. Franklin, p. 24.

Research Associates, with almost the same total production loss number as the EPA report, as shown below:

	FEA—Interior	EPA	NERA
Steep-slope mines in Appalachia	Up to 52	76.2	59
Small mines	Up to 44	12.5	29
Western river valleys	Up to 66	1.0	1
Total	Up to 162	89.7	86

Another newspaper, the *Chicago Tribune*, in discussing the matter on June 8,[79] made the cogent comment that:

> with the experts at odds, how can the layman decide whether avid environmentalists are trying to hold the economy hostage to their views or whether greedy coal and electric companies are trying to hoodwink the Administration? It isn't easy, but there are some forces which might be considered objective and there are ways of sorting out the total nonsense from the truly debatable points.

In his sorting, reporter Margolis cited a consulting firm that does a lot of work for the FEA—Energy and Environmental Analysis, Inc.—which concluded in a preliminary study that the bill would cut projected coal production by only 27 to 32 million tons per year. The firm, Margolis reported, was denied a contract by the FEA to make a more thorough study of the problem.

Margolis also referred to a study done by the Library of Congress' Environmental Policy Division, which concluded that the bill's impact on coal prices, production, and employment would be minimal. Margolis wrote,

> Even proponents of the bill agree that some small mines would have to close down or at least move if the bill became law. This might cause some short-term loss of production and, in the words of the Library of Congress study, "some short-term dislocation" of jobs, meaning unemployment.

The vote to override and subsequent events.—On June 10 the House floor debate on H.R. 25 took place and the recorded vote was: yeas 278, nays 143, present 1, not voting 12. Thus the two-thirds majority needed to override a veto was narrowly missed, by only three votes. On June 30, an article in the *Baltimore Sun* by Stephen E. Nordlinger [80] gave the results of his 3-week study of the methods used by experts in the Bureau of Mines and the Federal Energy Administration to compile their figures. Nordlinger reported that:

(1) These figures "appear to have been based on the roughest kind of estimates, verified in part by checking with State mining association officials who were known vocal opponents of the legislation."

(2) A memo written at the Interior Department referred of some of the figures as "murky."

(3) One Bureau of Mines official interviewed said that a lot of guessing had been done to compile the information to support the veto.

Nordlinger's article went on to cite some seven shortcomings which dealt with specific details of the matter.

In the same issue of the Congressional Record, Senator Metcalf introduced an article that had been published in the Louisville *Courier*

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[79] "Strip mining bill," by Jon Margolis, *Section 1*, p. 18.

[80] "Further Evidence of False Basis for Strip Mining Veto," Statement by Senator Metcalf in introducing Nordlinger's *Baltimore Sun* article, entitled "Coal-Veto Data Held Sloppy" *Cong. Record*, July 8, 1975 p. S 12019–S 12020.

Journal, June 30. Ward Sinclair, writing under the title, "Data Used to Justify Strip-Mine Bill Veto Questioned," dealt with the same matter in essentially the same manner. The articles by Nordlinger and Sinclair are reproduced herein, as Appendix XI.

Energy Information Act testimony

Nine months later, on March 3, 1976, Nordlinger and Sinclair repeated the substance of the above statements in a hearing on S. 1864 (Energy Information Act) before the Subcommittee on Energy Research and Water Resources of the Senate Committee on Interior and Insular Affairs. Senator Haskell, chairman of the Subcommittee, attempted to determine if the Bureau's numbers were based on a systematic and thorough canvass, but the two reporters responded that the Bureau's survey was informal and nonscientific. (See Appendix XI.)

At that same hearing on March 3, 1976, the FEA and the Bureau of Mines were castigated by Walter Heine, Associate Deputy Secretary for Mines and Land Protection in the Pennsylvania Department of Environmental Resources, as follows:

> . . . We can ill afford to repeat the same type of scenario which surrounded the President's veto of the proposed Surface Mining Act (H.R. 25) last May when the Federal agencies scrambled to acquire data upon which to recommend to the President a course of action.
>
> Those agencies should have had available to them, in a readily retrievable fashion, information on numbers and types of coal companies, their locations, the topography of the land on which the surface mines are located, the depth of overburden, the method of operation, etc, all . . . pertinent to energy decision-making, and certainly pertinent to making a decision on whether or not to veto the Federal strip mining bill.
>
> These data should have been subject to easy electronic analyses so that production could be related to coal prices, the economy, strikes, and so forth.[81]

Continuing, Heine referred to the Bureau of Mines "estimate of 40 to 162 million tons of coal production lost in the first full year of implementation of H.R. 25, and that "one-third to one-half of that amount was attributed [by the Bureau] to the closing of small coal mines [having a] . . . production of less than 50,000 tons per year, principally . . . in the east."

On the contrary, Heine stated, "environmental protection standards comparable to those in H.R. 25 are now in effect in Pennsylvania, and have been for over 10 years." He noted that a spokesman for the Pennsylvania surface mine industry recently told him that half of the Pennsylvania surface miners produce less than 50,000 tons per year and therefore would be classed as small operators. And yet, Heine remarked, Pennsylvania's surface mine coal production has increased over 30 percent in the last 3 years.

However, he stated:

> This type of information was never requested of us by the U.S. Bureau of Mines or the FEA, nor were we asked by these agencies to substantiate our figures, even after we supplied these data to the congressional committees during the drafting of the bill.
>
> In fact, a check into my telephone log and notes and discussions with the technical staff of our surface mining control agency does not reveal any substantive communications, oral or written, with the Bureau of Mines or FEA officials concerning the probable impact of the bill.

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[81] Transcript, hearing on S. 1864, Energy Information Act, before the Senate Subcommittee on Energy Research and Water Resources, Mar. 3, 1976, p. 68.

On May 22, 1975 . . . 2 days after President Ford announced his veto, I received calls from both the FEA and the Bureau of Mines requesting data on the effect of the Pennsylvania law on the operators. On May 27, 1975, another 5 days, I received another call concerning the number of small Pennsylvania operators mining [in] areas where the ground slope exceeds 20 degrees. All of these calls preceded Congresswoman Mink's hearing on the veto of June 3, 1975. (ibid, p. 69–70).

FEA Administrator Frank Zarb, in a continuation of the hearing on S. 1864, the Energy Information Act, responded in part to these criticisms by stating:

We run into difficulties when we run into political discussions. [With regard to strip mining, there was great opportunity to take the data available and create this kind of conclusion or that kind of conclusion. We were honest and open. The range is from here to here [gesturing]. Honestly, we cannot tell how the courts are going to rule on this vague provision or that vague provision.[82]

Considerable discussion ensued regarding letters that Senator Jackson and Senator Metcalf had written to President Ford in July 1975, asking for an analysis of the questions raised by reporters Nordlinger and Sinclair regarding the methodology used by experts in the Bureau of Mines and the FEA, in arriving at numbers that showed losses expected because of the implementation of H.R. 25. The lack of response by the executive departments was explained during the following exchange between Senator Haskell and Dr. William Fisher, then Acting Assistant Secretary for Energy and Minerals of the Department of the Interior, and Raymond A. Peck, Jr., Fisher's Deputy:

Senator HASKELL. Dr. Fisher . . . If you were in the room this morning you heard me ask Mr. Zarb about a letter addressed to the President by Senator Jackson and Senator Metcalf asking for an analysis of a newspaper article severely critical of your Department and the FEA on the methodology of [collecting] information used to support the veto on the strip mining bill. . . . Do you recall this letter?

Doctor FISHER. It was never received at the Department of the Interior. . . . [to Peck] Do you recall if it was received at FEA or not?

Mr. PECK. I checked at Mr. Hill's office [Deputy FEA Administrator] . . . and it was not received by their corresponding secretary either. We have a copy which we received this morning, or FEA received this morning, Mr. Hill's office, and our office will undertake a hasty response.

Senator HASKELL. It is probably sitting in the repositories of the in-basket.

Mr. PECK. Mr. Hill was under the impression it had been responded to directly by the White House (*ibid.*, p. 127).

Senator HASKELL. Well, now that the mail has been delivered, so to speak, if you could undertake an analysis . . .

Doctor FISHER. If it is a letter we will certainly respond to it.

Mr. PECK. We had undertaken an analysis at the [that] time independently of the two articles that appeared on June 30, [1975], and had prepared and submitted to Mrs. Mink [Chairman of Subcommittee on Mines and Minerals of the House Committee on Interior and Insular Affairs] some data . . . on July 1976, [but] . . . not . . . in time to make the printed proceedings.

Senator HASKELL. We would like to include a critique on how your Department and FEA went about gathering information to support the veto. . . . What Senator Jackson and Senator Metcalf wanted, was your response to the reporters' articles . . .

Doctor FISHER. We will respond to the letter now that we have finally received it. (*ibid.*, p. 127–128).

Another question concerned the Skelly-Loy report, entitled "Economic Engineering Analysis of U.S. Surface Coal Mines and Effective Land Reclamation". Senator Haskell had asked Pennsylvania's

[82] *Ibid.*, Mar. 8, 1976, p. 29.

Walter Heine "what that study would have revealed to us as to the adverse impact of the . . . strip mining legislation then passed by Congress," and Mr. Heine had responded—

My cursory review of the study indicated that the cost for reclamation and studies . . . [required] to meet H.R. 25 would not be prohibitive to the mines in Pennsylvania. . . . In fact, our experience . . . in our state indicates that, if anything, their costs were a little on the high side. (*ibid.*, March 3, 1976, p. 73).

The exchange between Senator Haskell and Mr. Heine continued:

Senator HASKELL. Now the Bureau of Mines did contact you in this period, did they not?

Mr. HEINE. After the veto.

Senator HASKELL. . . . Did they make any reference to the Skelly and Loy study?

Mr. HEINE. No.

Senator HASKELL. Of course, they've had it since February 1975. (*ibid.*, March 3, 1976, p. 73).

On March 8, Senator Haskell pursued this matter of the Skelly-Loy study with FEA Administrator Zarb, as follows:

Senator HASKELL. . . . At the last hearing Dr. Heine . . . indicated [that] a detailed analysis of the economic impact of the surface mining regulations . . . known as the Skelly-Loy Studies . . . was available to the Administration prior to the veto . . . What does this study say about the economic impact of surface mining?

Mr. ZARB. Mr. Chairman, you are going to have the Department of Interior people here [today] and I am sure you can get into the specifics of their analysis of that bill.

Mr. HILL. I am not aware of that particular study. . . . (*ibid.*, March 8, 1976, p. 12–13).

Accordingly, Senator Haskell continued the dialog on the Skelly-Loy report with the Department of Interior representatives, as chronicled in the following exchange:

Senator HASKELL. . . . Are you familiar with . . . the Skelly-Loy report on the economic consequences of the strip mining bill?

Mr. PECK. Yes, I am familiar with it. At the time S. 425 was pocket vetoed by the President, that report had not been written. At the time the development of H.R. 25 was ongoing it had not been published. But the Bureau of Mines and Office of Coal Research did have advance copies of those portions that were completed, and it was in fact taken into account in our economic calculations. It was consulted . . .

We had some problems with [the report because] there is no inflation factor calculated in the economic numbers, and it was directed primarily toward the cost of that reclamation. [But] that is not a major element of dispute—the cost of reclamation [called for] the performance standards set forth in H.R. 25— . . . [because] there was never a significant difference in the Administration assessment and [those] of independent parties.

Senator HASKELL. Did you by chance give a copy of that report to either committee of the Senate or the House?

Mr. PECK. I am informed by Dr. Falkie, yes.

Senator HASKELL. Could you find out from Dr. Falkie who he gave it to?

Dr. FALKIE. We supplied copies of that report * * *, I believe, to Mrs. Mink.

Senator HASKELL. Perhaps you could supply for the record the person to whom and the day upon which the report was supplied. . . .

Dr. FALKIE. I think he is sitting up there [pointing to the staff behind the Committee], but we can check our records on that.

Senator HASKELL. You better let us know exactly when you did supply it. That seems to be a fairly pertinent point.

Mr. PECK. * * * We did not have it in completed form. It was not completed until after the veto.

Senator HASKELL. You did not even have it in preliminary form before the veto?

Mr. PECK. We had portions of it. Those portions completed, I am informed, were taken into account, but the published report was not taken into account.

Senator HASKELL. I am informed * * * [that] the report was finished in February 1975. Now if you will look at your records and let me know if I am right or wrong . . . (ibid., March 8, p. 128–130).

The Skelly-Loy report had been delivered to the Bureau of Mines on February 13, 1976, and was being reviewed by that agency at the time of the Energy Information Act hearings, on March 3. From reviewing and analyzing the events of the past 18 months, including the testimony presented at the hearings on both the surface mine reclamation bills and the energy information bill, it is obvious that answers satisfactory to the Congress have not yet been presented by the Administration.

F. ENERGY INFORMATION

Bureau of Mines

One of the five major programs of the Bureau of Mines deals with data collection and analysis, for which the Bureau budgeted 9 percent of its funds in fiscal year 1976 (see Table 2). Approximately 10 percent of the Bureau's funds in the preceding fiscal year had gone for coal-related data collection and analysis.[83]

As pointed out in an earlier section of this report, the Bureau's collection of information and data and the analyses thereof are made on a worldwide basis, for the guidance of (1) U.S. industry in commercial operations, (2) the Federal and State and local governments in the United States, and (3) the Bureau's own research efforts. The Bureau maintains continuing surveillance and analysis of activities relating to the domestic and foreign coal industry, and other forms of energy.

The Bureau collects coal data from many sources by several methods, including canvass forms that cover approximately 6,000 respondents. These data cover all aspects of coal, from resources and reserves through production, processing, and transportation to end-use consumption. After they are validated, these data are incorporated into the Fuels Availability System (FAS), a computerized storage-retrieval system.

The Bureau disseminates its data and analysis through a number of media, such as the weekly and annual Mineral Industry Surveys for Bituminous Coal and Lignite, and for Anthracite. In addition, numerous other kinds of its publications contain coal statistical information, such as International Coal Trade, Information Circulars, Reports of Investigations, Bulletins, and Minerals Yearbooks. Furthermore, coal data and information are provided to requestors through letters and computer tapes and by telephone (24-hours-a-day service).

The validity attached to the Bureau's coal data and analysis rests heavily on the competence of its staff of engineers and economists whose knowledge of the coal industry depends on their understanding

[83] Two other Bureau of Mines programs had much greater percentages devoted to coal in fiscal year 1975—mining research (83 percent) and engineering evaluation, and demonstration (60 percent)—whereas metallurgy research had only 8 percent spent on coal-related work. (Statement by Dr. Thomas V. Falkie, prepared for the Energy Research and Water Resources Subcommittee of the Senate Committee on Interior and Insular Affairs, June 1975).

of the complex interrelationships among (1) technology, (2) financial markets, (3) supply and demand, and (4) physical characteristics of coal end products and the logistical systems by which coal is moved.

The Bureau of Mines maintains a substantial network of individuals and offices—its data-gathering effort. Its information is derived from a variety of sources,[84] including:

—38 State liaison officers (who cover all 50 States); [85]

—Four Regional Field Offices (Juneau, Spokane, Pittsburgh, Denver);

—90,000 individual respondents to more than 200 detailed surveys (most of which are monthly);

—Reports from foreign countries by U.S. mineral attachés and commercial counselors;

—Exchange of publications with U.S. governments (Federal, State, and local).

The data gathered by the Bureau, with appropriate safeguards to protect confidential information, is computerized; a new Burroughs 6700 System is online at Denver, and Bureau computers are linked with U.S. Geological Survey computers.

More than the mere handling of numbers is involved, because the collection and analysis of such information requires for each of the 100 different mineral commodities a knowledge of technology, specifications, and trade practices. Thus, the ultimate authority in the Bureau resides in the senior commodity specialist (generally a physical scientist or engineer), who has spent a large part of his professional career in close association with the commodity and its technology; these senior people have backgrounds in industry, university, other Federal agencies, or research laboratories of the Bureau of Mines.

In 1975, in order to facilitate interagency cooperation, the Bureau of Mines agreed to have each of its commodity specialists serve as the executive secretary for an interagency commodity committee—so as to develop information and propose solutions to problems that affect any Federal agency or the Federal Government, especially in the international arena.

When the Federal Energy Office was formed in 1973, the Bureau provided the FEO with its basic energy information, collection, and analysis system; in 1975 and early 1976 the Bureau became the single collection agency for the petroleum data needed by the Federal Energy Administration (successor to the FEO). These arrangements were established so as to avoid duplicate filing by industry, and duplicate handling by the Government.

GAO report

On December 2, 1975 the General Accounting Office issued a report (OSP–76–9) entitled "Federal Materials Research and Development; Modernizing Institutions and Management." The report dealt not only with materials research and development information—gathered by many Federal agencies—but also with the data collection and analysis activities of the Bureau of Mines in mineral supply and demand.

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[84] Statement of Dr. Jack A. Carlson, Assistant Secretary (Energy and Minerals), U.S. Department of the Interior, before the Special Subcommittee on Science, Technology, and Commerce of the Senate Commerce Committee, December 2, 1975.

[85] Described in earlier sections of this report.

In regard to the latter, the GAO expressed concern about the accuracy and validity of certain reports prepared by the Department of the Interior (Bureau of Mines and the U.S. Geological Survey), and noted that these reports could be improved by:

—using more current information.
—establishing certain guidelines to assure uniformity in the preparation of mineral estimates, and
—implementing review procedures that would help ensure their accuracy and reliability.

The GAO had reviewed two major annual reports of the Bureau of Mines, Commodity Data Summaries and Mineral Commodity Summary Tables—the former containing supply and demand statistics and estimates for 95 mineral, metal, and fuel commodities, and the latter containing statistics on 14 key commodities. Of the 95 commodities, the GAO report reviewed estimates on four commodities—bauxite, copper, fluorspar, and nickel. The GAO found the following deficiencies:

1—The published estimates were not always based on the most current information available;

2—The Department's specialists had different views regarding which information should be included in the estimates; and

3—Errors in computation and publication had not been detected.

Regarding No. 1, the GAO reported that the mineral specialists of the Bureau and the Geological Survey had said that other duties and lack of time were the reasons for not updating their estimates more often.

Regarding No. 2, the GAO noted that there were no specific standards to guide the specialists in reporting their mineral estimates. Thus, the specialists used their own judgment on (1) sources of information, (2) methodology and techniques of estimating, and (3) reporting format. The GAO expressed concern that the different views of these specialists "may affect the accuracy and consistency of report estimates on mineral availability."

Regarding No. 3, the need to review the estimates, the GAO reported that, of the four commodity reports, two (fluorspar and copper) were not adequately supported. In addition, the GAO noted a number of discrepancies between material on the same commodity presented in the Commodity Data Summaries and in the Mineral Commodity Summary Tables.

Thus, the GAO report recommended:

That guidelines for preparing mineral estimates be issued, emphasizing the need to use the latest available information and including sources of information to be used, methodology and techniques of estimation, and documentation to be prepared and retained in support of the published estimates; and

That review procedures be established to help ensure that the estimates are properly prepared and reported.

The GAO report, combined with Committee dissatisfaction with the Bureau of Mines data on the surface mining costs issue (see previous section herein), led the Senate Committee on Interior and Insular Affairs to conclude that it:

will not recommend any increases for data collection and analyses before (1) conducting its own oversight hearings and (2) receiving a report from the Department of the Interior describing what actions it intends to take with respect

to the recommendations of the General Accounting Office in the December 1975 report * * * [86]

ERDA authorization

The fiscal year 1976 authorization bills (S. 598 and H.R. 3474) for the Energy Research and Development Administration would expand ERDA's mission in the area of mining research and development, and the area of data collection.

In the House report on the ERDA Authorization bill (H.R. 3474) the Joint Committee "directed that ERDA establish a central source for information and develop, acquire and maintain information on all energy resources and technology, including proved and other reserves for the purpose of research and development.[87]

This establishment of a data-gathering function in ERDA would duplicate the data-gathering and analysis functions now conducted mainly by the U.S. Geological Survey and the Bureau of Mines * * * and the Federal Energy Administration * * * .

If additional energy information is required by ERDA * * * it would be much more effective and more economical to acquire * * * (it) through utilization of existing data-gathering and analysis capabilities instead of suffering the delays of developing new * * * facilities.[88]

A substitute amendment to the ERDA Authorization Act, submitted by Congressman Goldwater and accepted by the conferees on November 18, 1975, provided for ERDA to establish and maintain "a central source of information on all energy resources and technology in furtherance of the Administrator's research, development, and demonstration mission. * * *" The information would be made available to the public, except that the amendment protected against disclosure to the public of trade secrets or other proprietary information. The primary objective of the provision is to give ERDA a better and more accurate energy data base on which to make decisions concerning its R. & D. mission. Where necessary, ERDA is authorized to acquire proprietary and other data by negotiated purchase or by donation, but not by condemnation.[89]

In the discussion on the floor of the House on December 11, 1975, concern over data bank duplication was again expressed—by Congressman Goldwater, who said:[90]

ERDA would be required to duplicate the existing data bank activities of many Federal agencies, particularly those in the Interior Department and the Federal Energy Administration. * * * There were no formal hearings on the need for a new data bank within ERDA * * *. In the absence of a clear need for an ERDA data bank, as supported in appropriate hearings, I cannot justify the basic concept of a data bank * * *.

Energy Information Act

In February, 1974, 4 days of hearings on the Energy Information Act were held by the Senate Committee on Interior and Insular Affairs. As originally introduced, the bill (S. 2782) would have created a Bureau of Energy Information in the Department of Commerce, to

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[86] "Bureau of Mines," pp. 38-44 of Submittal of the Senate Committee on Interior and Insular Affairs to the Senate Budget Committee Pursuant to Section 301(c) of the Congressional Budget Act:" U.S. Cong., 94th, 2d sess., committee print, March 1976, 46 p.

[87] "Energy Resources Information," pp. 185-186 of "Authorizing Appropriations for the Energy Research and Development Administration for fiscal year 1976. . .": Joint Report of the Joint Committee on Atomic Energy and the House Committee on Science and Technology: U.S. Cong., 94th, 1st sess., H. Rept. No. 94-294, June 13, 1975.

[88] Remarks of Congressman Philip Ruppe on the floor of the House; during consideration of H.R. 3474: *Congressional Record*, June 19, 1975, p. H 5775.

[89] "Authorizing Appropriations for the Energy Research and Development Administration." Conference Report: U.S. Cong., 94th, 1st sess., H. Rept. No. 94-696, Dec. 8, 1975, p. p70.

[90] *Congressional Record*, Dec. 11, 1975, p. H 12380-H 12381.

operate a National Energy Information System like the Bureau of the Census—although some testimony during the hearings indicated a preference for an independent agency. In its last markup version, this bill would have completely changed and enlarged the role of energy-information analysis by the Federal Government.[91]

During the hearings,[92] the results of a General Accounting Office report on the energy needs of the Federal Government were presented.[93]

The GAO report had found that Federal efforts to collect, analyze, and report information on energy is both fragmented and uncoordinated—a situation that has existed for at least 12 years. The GAO report concluded that legislation was needed to establish a comprehensive Federal information system that would address current deficiencies and provide objective information capabilities that would be independent of energy policy analysis in the operating agencies.

The GAO study pointed out that 15 major Federal agencies were circulating 145 questionnaires, to obtain energy data from the private sector and from the States. This effort required 11 million responses that involved 3.6 million man-hours, annually. A number of policy problem areas were identified and discussed in the GAO report.

At the hearings, testimony was presented by the Federal Energy Office stating that the new energy-information functions should be lodged in that agency—or its successor, the Federal Energy Administration—rather than in an independent agency. The GAO report, however, was concerned about a potential conflict that would result from placing the policy formulation and basic data collection in the same agency—whether it be FEO or another energy-related agency.

The Energy Information Act was not enacted by the 93d Congress, and its successor (S. 1864) was introduced by Senator Gaylord Nelson in the 94th Congress in 1975. This bill has four principal purposes:

1. To establish an independent permanent Federal agency, to collect, analyze, and disseminate basic energy data and information;

2. To coordinate and consolidate the Federal collection of energy data, to insure the completeness and to minimize duplication in reporting by businesses in the energy industry;

3. To establish standards for handling the energy information that is gathered from individual companies, so as to strike a reasonable balance between the public's right to participate in national energy policy decisionmaking and the legitimate needs of private businesses for confidentiality;

4. To authorize a Federal program of systematically determining the location, extent, and value of the domestic energy resources of the United States.

In March 1976, Senator Haskell introduced an amendment to S. 1684 that would establish a National Energy Information Administration, which would be completely independent of the executive branch.[94] The energy-information functions now residing in the

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[91] Hughes, H. Steve, "Appraisal of Natural Resources Supply and Demand," from "Congress and the Nation's Environment; Environmental and Natural Resources Affairs of the 93d Congress," prepared for the Senate Committee on Interior and Insular Affairs: U.S. Cong., 94th, 1st sess., committee print, April 1975.

[92] "Energy Information Act," Hearings on Feb. 5–6 and 14–15, 1974 before the Senate Committee on Interior and Insular Affairs: U.S. Cong., 93d, 2d sess., Serial No. 93–94 (92–69).

[93] "Actions Needed to Improve Federal Efforts in Collecting, Analyzing, and Reporting Energy Data: U.S. General Accounting Office, B–178205, Feb. 6, 1974, 65 p.

[94] *Congressional Record*, February 26, 1976, p. S2499–S2500.

U.S. Bureau of Mines and the Federal Energy Administration would be transferred to the NEIA, where they would form the core of the new agency. The Administrator would carry out a comprehensive review of the energy information needs of each of the Federal agencies; this would form the basis for a plan to be implemented within 1 year, to transfer to the new agency all energy-information functions that resided in those other Federal agencies. Furthermore, information would be collected by NEIA on a mandatory basis.

The Subcommittee on Energy Research and Water Resources held hearings on March 3, 8, 9, and 12, and on April 2, 1976. Testimony was presented by a number of individuals, representing governmental agencies, universities, industrial organizations, and public interest groups, on both sides of the issue. In addition, there were several witnesses who noted both favorable and unfavorable aspects of the legislation.

The record of the hearings, which has not yet been published—August 15, 1976—will contain a comprehensive airing of the energy-information issue, and will contribute to a thorough understanding of this critical matter. The markup has not been scheduled as yet.

APPENDIXES

Appendix I

List of Mineral Materials Present in the U.S. Strategic and Critical Materials Stockpile, as of June 30, 1975

75-682—76——12

List of Mineral Materials Present in the U.S. Strategic and Critical Materials Stockpile, as of June 30, 1975

Aluminum
Aluminum oxide, abrasive grain
Aluminum oxide, fused, crude
Antimony
Asbestos, amosite
Asbestos, chrysotile
Asbestos, crocidolite
Bauxite, metal grade, Jamaica type
Bauxite, metal grade, Surinam type
Bauxite, refractory grade
Beryl ore (11 percent BeO)
Beryllium-copper master alloy
Beryllium metal
Bismuth
Cadmium
Celestite
Chromite, chemical grade
Chromite, metallurgical grade
Chromite, refractory grade
Chromium, ferro, high carbon
Chromium, ferro, low carbon
Chromium, ferro, silicon
Chromium, metal
Cobalt
Columbium carbide powder
Columbium concentrates
Columbium, ferro
Columbium, metal
Copper
Diamond dies, small
Diamond, industrial, crushing bort
Diamond, industrial, stones
Fluorspar, acid grade
Fluorspar, metallurgical grade
Graphite, natural, Ceylon
Graphite, natural, Malagasy
Graphite, natural, other, crystalline
Iodine
Jewel bearings
Kyanite-mullite
Lead
Magnesium
Manganese, battery grade, natural ore
Manganese, battery grade, synthetic dioxide
Manganese ore, chemical grade, type A
Manganese ore, chemical grade type B
Manganese ore, metallurgical grade
Manganese, ferro, high carbon
Manganese, ferro, low carbon
Manganese, ferro, medium carbon
Manganese metal, electrolytic
Manganese silicon
Mercury
Mica, muscovite block, stained and better
Mica, muscovite film, first and second qualities
Mica, muscovite splittings
Mica, phlogopite block
Mica, phlogopite splittings
Molybdenum disulphide
Molybdenum ferro
Molybdic oxide
Nickel
Platinum group metals, iridium
Platinum group metals, palladium
Platinum group metals, platinum
Quartz crystals
Rare earths
Rutile
Sapphire and ruby
Silicon carbide
Silver
Talc, steatite block and lump
Talc, steatite ground
Tantalum carbide powder
Tantalum metal
Tantalum minerals
Thorium
Tin
Titanium sponge
Tungsten carbide powder
Tungsten, ferro
Tungsten metal powder, carbon reduced
Tungsten metal powder, hydrogen reduced
Tungsten ores and concentrates
Vanadium pentoxide
Zinc

Source: "Stockpile Report to the Congress, July–December, 1975": General Services Administration, Federal Preparedness Agency, IRCN, 1087-GSA-SA, April 1976, pp. 5-8, 10.

Appendix II

Groupings of Metals and Nonmetals

Groupings of Metals and Nonmetals

Metals

Iron: iron ore.
Iron alloy: manganese ore, chromite, nickel, molybdenum, cobalt, and vanadium.
Base: copper, lead, zinc, and tin.
Light: aluminum, magnesium, and titanium.
Precious: gold, silver, and platinum.
Rare: uranium, radium, and beryllium.

Nonmetals

Building: sand and gravel, limestone, and cement materials.
Chemical: sulfur and salt.
Fertilizer: phosphate rock, potash, and nitrates.
Ceramic: clay and feldspar.
Refractory and flux: clay and magnesia.
Abrasive: sandstone and industrial diamonds.
Insulant: asbestos and mica.
Pigment and filler: clay, diatomite, and barite.
Precious and gem: gem diamonds and amethyst.

Source: McDivitt, James F., *Minerals and Men*; The Johns Hopkins Press, 1965, Fig. 1.

Appendix III

Frequency of Regularly Issued Bureau of Mines Commodity Reports

Frequency of Regularly Issued Bureau of Mines Commodity Reports

(W=weekly, M=monthly, Q=quarterly, A=annually)

Mineral Industry Surveys

Abrasive materials (A)
Aluminum (M, A)
Antimony (Q, A)
Asbestos (A)
Barite (A)
Bauxite (Q)
Beryllium (A)
Bismuth (Q, A)
Boron (A)
Bromine (A)
Cadmium (Q, A)
Calcium magnesium chloride (A)
Carbon black (Q, A)
Cement (M, A)
Cesium and rubidium (A)
Chromium (M, A)
Clays (A)
Coal, bituminous (W, A)
Coal, bituminous distribution (Q)
Coal, anthracite (W, A)
Coal, anthracite distribution (A)
Cobalt (M, A)
Cobalt refiners (Q)
Coke and coal chemicals (M, A)
Coke distribution (A)
Coke producers (A)
Columbium and tantalum (A)
Copper industry (M, A)
Copper production (M)
Copper sulfate (Q)
Diatomite (A)
Feldspar (A)
Ferroalloys (semiannual)
Ferrosilicon (Q, A)
Fluorspar (Q, A)
Gem stones (A)
Gold and silver (M, A)
Graphite (A)
Gypsum (M, A)
Iodine (A)
Iron and steel (A)
Iron and steel scrap (M, A)
Iron ore (M, A)
Kyanite and related materials (A)
Lead industry (M, A)
Lead, primary production (M)
Lime (M, A)
Liquefied petroleum gasses and ethane sales (A)
Lithium (A)
Magnesium, primary (Q, A)
Magnesium and magnesium compounds (A)
Manganese (M, A)
Mercury (Q, A)
Mica (A)
Mineral production, world (A)
Minor nonmetals (A)
Molybdenum (M, A)
Natural gas (M, A)
Natural gas liquids (M)
Natural gas processing plants (biannually)
Natural gas production, world (A)
Nickel (M, A)
Nitrogen (A)
Peat (A)
Peat producers (A)
Perlite (A)
Petroleum and petroleum products:
- Asphalt sales (A)
- Aviation turbine fuels (A)
- Burner fuel oils (A)
- Crude oil production, world (A)
- Crude oil and products pipeline mileage (triannually)
- Diesel fuel oils (A)
- District V petroleum statement (M, A)
- Fuel oil and kerosine sales (A)
- Fuel oils by sulfur content (M)
- Motor gasolines (summer) (A)
- Motor gasolines (winter) (A)
- Petroleum refineries in United States (A)
- Petroleum statement, advance release (M)
- Petroleum statement (M, A)

Phosphate rock (M, A)
Platinum group metals (Q, A)
Potash (A)
Pumice and volcanic cinder (A)
Rare earth elements and thorium (A)
Rhenium (A)
Salt (A)
Sand and gravel (A)
Selenium (Q)
Selenium and tellurium (A)
Slag, iron and steel (A)
Sodium compounds (A)
Stone (A)
Sulfur (M, A)
Talc, soapstone, and pyrophyllite (A)
Tin (M, A)
Titanium (Q, A)
Tungsten (M, A)
Uranium (A)
Vandium (M, A)
Vermiculite (A)
Zinc industry (M, A)
Zinc production (M)
Zinc oxide (M)
Zirconium and hafnium (A)

Other Reports

Commodity Data Summaries (covers 95 commodities) (A)
Minerals and Materials (covers 15 commodities) (M)
International Coal Trade (M)
International Petroleum Annual (A)
Mineral Trade Notes (M)
Minerals Yearbook, volume I (covers 92 commodities) (A)
Minerals Yearbook, volume II (covers 50 States) (A)
Minerals Yearbook, volume III (covers 157 countries) (A)
Mineral Facts and Problems (covers 89 commodities) (every 5 years)

Source: U.S. Bureau of Mines.

Appendix IV

List of State Liaison Officers of the U.S. Bureau of Mines

List of State Liaison Officers of the Bureau of Mines

Alabama
James R. Boyle, U.S. Bureau of Mines, P.O. Box L, University, Ala. 35486

Alaska
Alfred L. Service, U.S. Bureau of Mines, Room G–81, Federal Bldg., Anchorage, Alaska 99501

Arizona
Joseph C. Arundale U.S. Bureau of Mines, Room 1012, 2721 N. Central Ave., Phoenix, Ariz. 85004

Arkansas
Raymond B. Stroud, U.S. Bureau of Mines, Room 3331, Federal Office Bldg., Little Rock, Ark. 72201

California
William H. Kerns, U.S. Bureau of Mines, Room 3046, 650 Capitol Mall, Sacramento, Calif. 95814

Colorado
Joseph B. Smith, U.S. Bureau of Mines Bldg. 20, Denver Federal Center, Denver, Colo. 80225

Connecticut
William R. Barton,
see New Hampshire

Delaware
Joseph A. Sutton,
see Maryland

Florida
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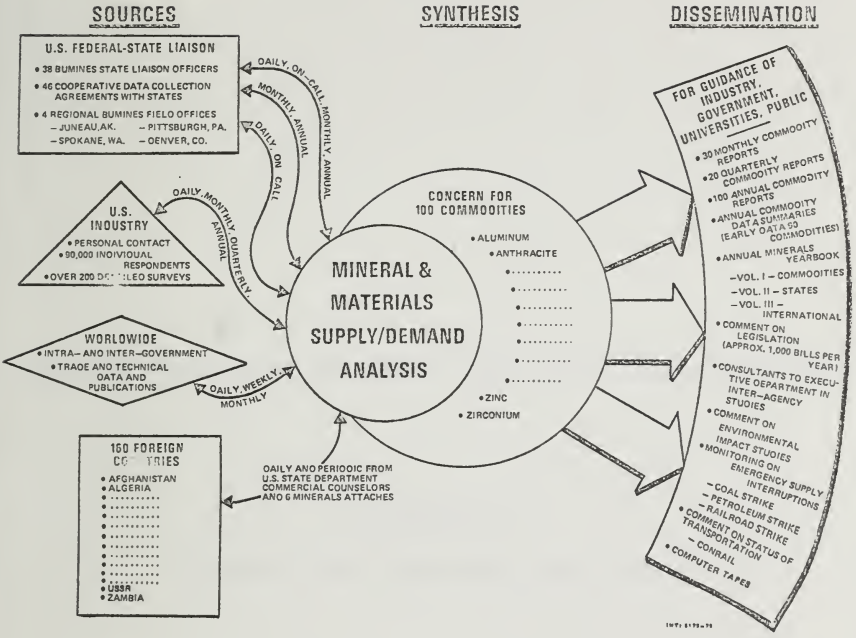
Source: U.S. Bureau of Mines.

Appendix V

Flow Diagram of Supply—Demand Analysis

75-682 O—76——13


SOURCES
SYNTHESIS
DISSEMINATION
U.S. FEDERAL-STATE LIAISON
• 38 BUMINES STATE LIAISON OFFICERS
• 46 COOPERATIVE DATA COLLECTION AGREEMENTS WITH STATES
• 4 REGIONAL BUMINES FIELD OFFICES
– JUNEAU, AK. – PITTSBURGH, PA.
– SPOKANE, WA. – DENVER, CO.
DAILY, ON-CALL, MONTHLY, ANNUAL
MONTHLY, ANNUAL
DAILY, ON CALL
U.S. INDUSTRY
• PERSONAL CONTACT
• 90,000 INDIVIDUAL RESPONDENTS
• OVER 200 DETAILED SURVEYS
DAILY, MONTHLY, QUARTERLY, ANNUAL
WORLDWIDE
• INTRA– AND INTER–GOVERNMENT
• TRADE AND TECHNICAL DATA AND PUBLICATIONS
DAILY, WEEKLY, MONTHLY
160 FOREIGN COUNTRIES
• AFGHANISTAN
• ALGERIA
• USSR
• ZAMBIA
DAILY AND PERIODIC FROM U.S. STATE DEPARTMENT COMMERCIAL COUNSELORS AND 6 MINERALS ATTACHES
MINERAL & MATERIALS SUPPLY/DEMAND ANALYSIS
CONCERN FOR 100 COMMODITIES
• ALUMINUM
• ANTHRACITE
• ZINC
• ZIRCONIUM
FOR GUIDANCE OF INDUSTRY, GOVERNMENT, UNIVERSITIES, PUBLIC
• 30 MONTHLY COMMODITY REPORTS
• 20 QUARTERLY REPORTS
• 100 ANNUAL COMMODITY REPORTS
• ANNUAL COMMODITY DATA SUMMARIES (EARLY DATA 93 COMMODITIES)
• ANNUAL MINERALS YEARBOOK
– VOL. I – COMMODITIES
– VOL. II – STATES
– VOL. III – INTERNATIONAL
• COMMENT ON LEGISLATION (APPROX. 1,000 BILLS PER YEAR)
• CONSULTANTS TO EXECUTIVE DEPARTMENT IN INTER–AGENCY STUDIES
• COMMENT ON ENVIRONMENTAL IMPACT STUDIES
• MONITORING ON EMERGENCY SUPPLY INTERRUPTIONS
– COAL STRIKE
– PETROLEUM STRIKE
– RAILROAD STRIKE
• COMMENT ON STATUS OF TRANSPORTATION
– CONRAIL
• COMPUTER TAPES

Appendix VI

Helium Cases That Have Been Settled

Helium Cases That Have Been Settled

1. *Navajo Tribe of Indians* v. *The United States of America* (No. 49692) in the U.S. court of claims.

This action involved a deposit of helium-bearing, noncombustible gas in the Rattlesnake Field on the Navajo Indian Reservation near Shiprock, N. Mex. The Bureau of Mines acquired ownership of the gas in the field for processing for helium extraction at its Navajo Helium Plant at Shiprock. The United States paid advance royalty in 1947 on the volume of gas estimated to be in place in the reservoir. The royalty was based on a gas value of 12 cents per 1,000 cubic feet., Two or three years later, the Navajo Tribe sued for additional payment. On July 15, 1966, the court of claims concluded that the plaintiff was entitled to recover $261,037.99 plus interest at the rate of 4 percent per year from 1947 to date of payment.

2. *Caroline Bush Emeny, et al* v. *The United States of America* (No. 317–66) in the U.S. court of claims.

The plaintiffs in this action were the surface estate owners and claimed to be owners of the storage rights in Cliffside Field, Potter County, Tex., where the United States was storing helium for conservation and future use. Plaintiffs alleged that the United States had taken their storage rights under the power of eminent domain. The United States contended that it had the right to store helium in the field because it had purchased the gas rights many years ago from the plaintiffs' predecessors. The court found that the United States had not acquired storage rights along with the gas rights and that the landowners were entitled to recover just compensation for the rights taken from them. On December 17, 1975, the court concluded that the plaintiffs were entitled to recover $221,880 plus interest computed at a rate of 4 percent per year from January 5, 1963, to the time of payment as just compensation for the storage rights. In addition plaintiffs were awarded $341,346.60 as reimbursement for costs incurred in prosecuting their case.

3. *Air Reduction Company, Inc., et al* v. *Udall* (Civil Action No. 2880–68) in the U.S. District Court for the District of Columbia, and No. 22–847 in the U.S. Court of Appeals for the District of Columbia Circuit.

This action was bought in November 1968, by three private helium distributors and producers, to enjoin the Secretary of the Interior from enforcing proposed new regulations governing the purchase of helium by Government contractors and subcontractors. On December 9, 1968, the district court held that the Secretary had exceeded his authority under the Helium Act Amendments of 1960 (50 U.S.C. 167 et seq.) and permanently enjoined the Secretary from enforcing regulations requiring Government contractors and subcontractors to purchase helium from the Bureau of Mines. On September 2, 1969, the court of appeals affirmed the judgment of the district court.

Source: R. D. Munnerlyn, U.S. Bureau of Mines, May 3, 1976.

Appendix VII

Memorandum of Understanding Between the Bureau of Mines and the Mining Enforcement and Safety Administration

Memorandum of Understanding Between the Bureau of Mines and the Mining Enforcement and Safety Administration

Whereas, the Secretary of the Interior has delegated to the Bureau of Mines (hereinafter called BOM) the management responsibility for and conduct of mine health and safety research programs authorized under the Federal Metal and Nonmetallic Mine Safety Act of 1966 and the Federal Coal Mine Health and Safety Act of 1969, and has delegated to the Mining Enforcement and Safety Administration (hereinafter called MESA) mine health and safety, assessment and compliance, and education and training functions under these acts;

Whereas, these delegations of authority from the Secretary are set forth in the Secretary's Order No. 2953, dated May 7, 1973, and in the Departmental Manual at 215 DM 9.1, 218 DM 1 and 218 DM 2, all of which are hereby incorporated by reference as though fully set forth herein;

Whereas, the Assistant Secretary, Energy and Minerals, by memorandum of June 19, 1975, to the Director, BOM, and the Administrator, MESA, has specified certain procedures and directives to achieve improved coordination between BOM and MESA regarding mine health and safety research;

Whereas, both BOM and MESA desire to strengthen their cooperation in achieving the Department of the Interior's goal of improving the health and safety of the Nation's miners:

Now, therefore, in order to insure full and effective use of the capabilities and resources of BOM in managing and conducting research and of the capabilities and resources of MESA to assist in planning research and to assure maximum utilization of technologic developments resulting from mine health and safety research, BOM and MESA agree as follows:

(*1*) *Management, coordination, and conduct of research.*—BOM shall manage and conduct the mine health and safety research programs referred to herein and shall provide overall coordination for the mine health and safety research programs including the assessment and prioritization of all input on research needs and the formulation of a balanced overall program at projected budgetary levels in a standard format bearing approval of the Director. BOM shall coordinate such management and conduct with MESA. Such coordination shall include:

(a) Establishment of explicit methodology and criteria for defining and selecting research needed to solve problems identified from analysis of mine accidents, safety and health hazards, and standards compliance experience;

(b) Joint use of the methodology to formulate research programs from inputs received from all sources including that solicited from the mining industry, labor organizations, other governmental organizations, and the academic community;

(c) Joint review and evaluation of ongoing programs;

(d) Assurance that research contractors follow MESA procedures for obtaining any required approvals of equipment, materials, or procedures to be used;

(e) Joint development of strategies for utilization of research results by delineating requirements for field testing and demonstration to validate new technology; disseminating potential use information to the mining community and/or developing rules and regulations for its use;

(f) MESA representation, at the request of the Director or the Administrator, in preparing RFP's and on technical evaluation committees for mine health and safety research contracts; and

(g) MESA review, at the request of the Director or the Administrator, of draft final reports on mine health and safety research contracts.

(*2*) *Advice and assistance from MESA.*—MESA shall provide advice and assistance to BOM in BOM's management and conduct of the mine health and safety research programs referred to herein. Such advice and assistance shall include:

(a) Provision of such information on health and safety hazards, accidents, injuries, fatality investigations, compliance, and training as necessary for the purposes of research planning and evaluations;

(b) Advice on both an as-indentified basis and on an annual budget cycle planning basis of health and safety problems requiring research. Research input will be provided to BOM in a mutually agreed upon format;

(c) Participation with BOM through the life cycle of research projects that impact MESA responsibilities in developing and enforcing standards, solving compliance problems, and training (such participation may include advising, monitoring and review functions for purposes of assuring adequacy and proper timing control);

(d) Coordination of activities of MESA's research review committees with BOM's standards input committees;

(e) Advice, at the request of BOM, on health and safety aspects of mining research projects conducted under programs other than health and safety research; and,

(f) Maintenance within MESA of a coordinating staff for the purpose of carrying out the functions agreed to by MESA herein (such staff to be fixed and adjusted from time to time by the Administrator of MESA in accordance with budgetary and personnel requirements).

(*3*) *Coordination in standards development.*—MESA shall advise BOM of its plans for developing and revising standards for the purposes of allowing sufficient opportunity for technical consultation between MESA and BOM prior to publication of such standards as proposed rule making. BOM shall advise MESA of research results which can impact existing or proposed standards through input from BOM standards committees.

(*4*) *Implementation.*—To effectively implement this memorandum of understanding, BOM and MESA shall:

(a) Conduct their responsibilities pursuant to this memorandum jointly and in a manner to minimize cost and time and to meet budget and program deadlines;

(b) Develop joint research strategy on the solution of mine health and safety problems; program thrusts will be established jointly for short, intermediate, and long-term (5-years or more) objectives with program balance to be established by BOM;

(c) Utilize the methodology and criteria approved by the Assistant Secretary, Energy and Minerals, for selecting and evaluating programs and projects that is described in ad hoc committee research task force report dated November 1975 and hereby incorporated by reference as though fully set forth herein;

(d) Exchange annual and long-range plans, as well as general program plans and supportive appropriations requests;

(e) Utilize, to the extent possible, meeting of peer groups from both BOM and MESA, but in any event carry out research evaluations on an annual basis by such peer groups in accordance with the approved methodology and criteria; and,

(f) Identify a percentage of available funds in each fiscal year for preemption in the event of contingencies, including but not limited to research of opportunity identified by MESA, cost overruns, and research necessary to aid during mine rescue emergencies;

(g) Identify key personnel responsible for coordination of information exchanged between BOM and MESA relative to research and/or standards. Coordinators for research input to BOM will be named by the Administrator, including research coordinators for coal, metal/nonmetal, and the special areas of education and training and technical support. Coordinators for standards input to MESA will be named by the Director, including standards coordinators for coal and metal and nonmetal mining;

(h) Hold formal meetings between Bureau and MESA coordinators at least 12 months in advance of the start of the BOM's budget cycle to prepare strategy papers and update long-term plans;

(i) Develop joint issue papers, congressional testimony, et cetera, whenever appropriate.

(*5*) *Applicability, modification, and termination.*—This memorandum of understanding and the specific provisions contained herein shall govern the activities of BOM and MESA pertaining to mine health and safety research and standards formulation affected by that research. To the extent that specific provisions herein are inconsistent with the Secretary's Order No. 2953, and the provisions of the Departmental Manual, the Secretary's Order and the Departmental Manual shall govern such activities. This Memorandum of Understanding shall remain in effect until modified or terminated by mutual consent of BOM and MESA, or by Secretarial action, or by operation of law.

In witness whereof, the agencies hereto have made and executed this Memorandum of Understanding on the 6th day of February 1976.

THOMAS V. FALKIE,
Director, Bureau of Mines.
ROBERT E. BARRETT,
Administrator, Mining Enforcement and Safety Administration.

Approved February 6, 1976.
WILLIAM L. FISHER,
Acting Assistant Secretary of the Interior.

Appendix VIII

Publications of the Bureau of Mines

Publications of the Bureau of Mines [1]

The Bureau of Mines makes the findings of its scientific and technical studies available through its own publications and through papers presented before scientific and technical societies and published in their periodicals, and through contributions to trade journals. In addition, the Bureau stocks and maintains a free-loan library of information movies on all phases of the mineral industries.

The Bureau's own publications include Reports of Investigations, Information Circulars, Technical Progress Reports, Mineral Industry Surveys, mostly distributed free, in limited numbers, from the Bureau's Pittsburgh facility; Bulletins, Handbooks, Minerals Yearbook, Special Reports, Popular Pamphlets, mostly sold by the Superintendent of Documents.

In addition, numerous Bureau reports are open filed and available for inspection in Bureau libraries, and others are published by the National Technical Information Service of the U.S. Department of Commerce. (See Table VIII–1.)

Reports of Investigations and Bulletins present the results of original research, the latter usually being final reports on major projects or on major phases of continuing projects. Information Circulars may summarize information previously published in several Reports of Investigations or Bulletins or from sources outside the Bureau, or may present observations of Bureau personnel at cooperating mines and plants.

The Mineral Industry Surveys, which give current economic and statistical data on mineral commodities and safety records, are issued regularly—weekly, monthly, quarterly, and/or annually.

The Bureau's loan library of motion pictures is used by high schools and universities, by scientific and technical societies, by civic groups, the Armed Forces, TV stations, and other organizations. Bureau films are sponsored by industrial concerns, which pay all expenses of production and providing prints to the Bureau. The script is submitted to the Bureau before filming begins, and so is the film when nearing completion. This program, which has been in effect since 1919, provides no direct publicity to the companies except for a credit line on the film.

Bureau personnel present papers before scientific and technical societies or for publication in their periodicals, averaging about 350 per year.

In fiscal year 1975, a number of publications were issued in the several categories described above. (See Table VIII–1).

Table VIII–1. Bureau of Mines research publications, fiscal year 1975

Publication:	*Number of reports*
Bulletin	1
Information Circular	36
Minerals Yearbook (3 volumes)	1
NTIS	96
Open File	75
Report of Investigations	130
Special Report	3
Technical Progress Report	11

Appendix IX

Production Losses (Backup Data and Information) for Administration's Veto of H.R. 25

75-682 O—76——14

Production Losses[1]

III. Production Losses (Backup Data and Information)

Small mines.
Steep slopes.
Alluvial valley floors.
Other unquantifiable loss (list what and why).

Executive Summary

PRODUCTION LOSSES

I. General

A. Estimates were necessarily based on certain assumptions.

1. Losses are shortfalls from adjusted Project Independence projected gains (projected production=685 million tons).

2. Some parts of estimates are based on relative 1974–75 price levels of coal.

3. Assumed prevailing mining methods and technology.

4. Other supply and demand constraints may have a significant effect on increased coal production.

5. Rate at which productive system recovers will depend on time it takes industry to recover, which is limited in the short range.

II. Projected production losses

A. Total losses.

1. Total losses from three categories is 40 to 162 million tons.

2. Categories are: (a) small mines (22 to 52); (b) steep slopes, aquifer, siltation (7 to 44); (c) alluvial valley floor (11 to 66).

B. Methodology.

1. Small mines.

a. Estimated production from mines producing less than 50,000 tons per year is 60 million for 1977.

b. FEA conducted a survey of the Appalachian States and got an estimated loss of 52 million tons. Information was obtained from (1) the State regulatory authorities, (2) State reclamation associations and (3) companies whose figures were verified by 1 and 2 above.

c. Minimum figure of 22 based on engineering judgment that 60 percent of the 52 million tons could be mined and would not be lost.

d. 22 to 52 million tons represents 37 to 87 percent of projected small mine production (60 million tons).

e. Small operators would be impacted by the following:

(1) Increased production costs.

(2) Bonding and permit application requirements would cause a front end cost of 6 to 12 K.

(3) Lack of technical expertise readily available for deriving various application data including hydrologic data, detailed underground means, test borings, analysis of strata characteristics, detailed mining and reclamation plans and assessment of hydrologic impact.

(4) Additional equipment required to handle overburden in using haul back methods required because of no spoil on the downslope.

(5) Shortage of drilling equipment.

(6) Requirement that portion of bonding be held at least 5 years after last year of vegetation.

(7) Control of siltation including additional sediment control structures, drainage ditches, and water treatment facilities.

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[1] Source: "Surface mining veto justification briefing," Hearing, House Committee on Interior and Insular Affairs, June 3, 1975: U.S. Cong., 94th, 1st Ses. H. Serial No. 94-23, pp. 133-142

2. Steep slopes, aquifers, and siltation loss are 7 to 44 million tons.
(1) Steep slope losses are 7 to 25 million tons.
(a) Based on steep slope mining from mines greater than 50,000 tons per year.
(b) Projected production from such mines for 1977 is 68 million tons. Losses of 7 to 44 million tons are 10 to 35 percent of 68.
(c) FEA survey of small mines relating to steep slope provisions was taken into consideration. Also Ohio, West Virginia, and Tennessee production trends were considered. After strong State laws in these States were enacted, production decreased 20 to 30 percent.
(d) Operators would have trouble with the following:
(i) No variances, other than mountaintop mining.
(ii) No terracing.
(iii) No placement of spoil on downslope except initial cut.
(iv) Additional equipment needed for haulback or block-cut methods would be difficult to get quickly.
(e) Engineering judgment based on (c) and (d) above used to determine that 10 to 35 percent loss of 68 million tons would occur.
(2) Aquifers (loss is 0 to 9 million tons).
(a) Approximately 90 million tons were considered as base production not being affected by other loss categories.
(b) Engineering judgment of FEA and BOM personnel that up to 10 percent could be affected.
(c) Reasons are the following:
(i) Ground water hydrology may be disrupted whenever coal mining takes place.
(ii) Where coalbed serves as aquifer, interruption of aquifer could lower water, including wells.
(iii) Water quality may be changed.
(iv) Requirement of consent of water rights owners may further reinforce tendency toward strict interpretation of hydrologic features of the bill.
(v) Losses would depend greatly on interpretation of regulatory authorities and courts.
(3) Siltation (loss is 0 to 10 million tons).
(a) Based on engineering judgment of BOM and FEA personnel.
(b) Reasons are the following:
(i) Difficult for the operator to "affirmatively demonstrate" that he could comply with preventing additional contributions of suspended solids.
(ii) Sedimentation must be measured accurately prior to mining. Difficult to measure accurately and even if possible sedimentation during the first year may be higher than that measured due to natural causes and it would be difficult to prove it was not due to mining.
(iii) Difficult for some operators to economically construct additional diversion ditches, impoundment structures, and water treatment facilities required.
(iv) 515(b)(10)(C) requires removal of large siltation structures after revegetation and stabilization. This may not be of permanent nature.
3. Alluvial valley floors.
a. Estimated production west of 100th meridian is approximately 95 million tons in 1977.
b. Losses estimated at 11 to 66 million tons.
c. Many ambiguous terms such as significant, potential, and substantial.
d. Minimum 11 million tons loss was determined by:
(i) Examining three key factors (1) area now under intensive agricultural usage (including farming and hay meadows); (2) undeveloped rangelands and; (3) potential farming and ranching areas. These areas are uncertain on a national basis.
(ii) Considered coal actually under an alluvial valley floor.
(iii) If some of these mines could move to other areas which would be difficult, minimum loss could be 11 million tons. If none of these mines could move, minimum loss would be 24 million tons.
(v) Movement would require availability of reserves in areas not affecting A.V.F., equipment expansion, new mining and reclamation plans and in some cases, new permits.
(vi) According to Bucyrus-Erie for 60 cubic yard dragline delivery date would be fourth quarter 1979 plus 1 year for assembly.
(e) Maximum loss (66 million tons) based on the following:
(i) Assumed that any affect on hydrologic function of A.V.F. from tributaries, or ground water would preclude mining.

(ii) A.V.F. are dependent on small intermittent tributaries as well as major drainages with perennial streamflow.

(iii) When such streams and their water are affected by mining, the runoff into A.V.F. is also affected which is prohibited.

(iv) 66 million tons is based on projected percentage to 1977 from estimated amount affected in 1974.

4. Unquantifiable losses.

(1) Designation of areas as unsuitable for mining.

(a) Current operations not affected.

(b) Long-term production could be affected depending on areas not designated.

(2) Surface owner protection.

(a) Amount of Federal reserves under private surface is approximately 14.2 billion tons.

(b) Some of this will be lost depending on the number of owners who will give consent.

(c) Because of restrictions on the amount of compensation allowed number of owners giving consent may be limited.

(3) Permit application requirements.

(a) Affect an operators producing more than 50,000 tons per year.

(b) Acquisition of an analysis of application data required could have some effect on these mines.

(4) Consideration of State laws and effects.

(a) Effects on production in three States was examined. (Due to passage of their own laws, Ohio, West Virginia, and Tennessee.)

(b) Reasons for these States being used:

(i) Have stronger laws than other States which come closer to H.R. 25 standards.

(ii) Have been in effect long enough to show production trends.

(c) Ohio—Surface production increased every year for the past 10 years up to and including the year preceding surface law (38.6 million tons). Effective date, April 1972. Production for 1973 was 29.6 million tons. Decrease, 23 percent.

(d) West Virginia—Gradual increase in surface production up to the year preceding effective date of law (27.7 million tons). Production in 1973, 19.9 million tons. Decrease, 28 percent.

(e) Tennessee—Again gradual increase up to 5.7 million in the year preceding effective date of law (March 1972). 1974 production was 4.3 million tons. Decrease, 25.

(f) No certainty that drops were entirely due to laws, however, there are no other apparent reasons.

(g) These laws are still less restrictive than H.R. 25.

(i) Do not require all of application data.

(ii) Many more variances.

(iii) Do not require complete elimination of highwells in many cases. Allow terracing.

(h) These States have large portion of surface mining on steep slopes. 1971 figures are:

(i) Ohio—29 percent.

(ii) West Virginia—72 percent.

(iii) Tennessee—77 percent.

(iv) Pennsylvania not included.

(v) Steep slopes are a very small portion (25 percent) of surface mining within State.

(vi) Pennsylvania law has many variances and it does not appear that 1971 law changed many of the restrictions relating to steep slopes.

Projected Productions for 1977

1. Small mines producing less than 50,000 tons per year. (60 million tons projected).

Small mine production is estimated for 1974 at approximately 50 million tons. An increase of approximately 3 to 5 million tons per year was assumed over the next 3 years thereby bringing 1977 production up to approximately 60 million tons.

2. Steep slope production (110 million tons projected).

Steep slope production was derived by projecting the steep slope production of 1971 (80 million tons) as derived in the 1973 report prepared by the Council on Environmental Quality on coal surface mining and reclamation. It was assumed

that production from these areas would increase at a rate of approximately 5 million tons per year thereby reaching an estimated production in 1977 of 110 million tons.

3. Steep slope production from mines producing more than 50,000 tons per year. (68 million tons projected).

By obtaining from personnel within the Appalachian States, familiar with surface mining within each State, an estimate was obtained showing that approximately 70 percent of surface coal from mines producing 50,000 tons per year or less was being mined on steep slopes in 1974. This 70 percent was projected to 1977 which gives a small mine steep slope production of 42 million tons. Subtracting the 42 from 110 million tons projected total steep slope mining gives 68 million tons of projected steep slope mining at mines producing more than 50,000 tons per year in 1977.

4. Production West of 100th Meridian (95 million tons projected).

Production West of the 100th meridian was derived by examining those mines in production at present and using the predicted expansion at these mines to determine the 1977 production. Arizona excluded.

5. Total Surface Production (350 Million tons projected).

Projected production of total surface mining was derived from the project independence Report (Business as usual case as adjusted).

Production Losses

A. GENERAL

Interior and F.E.A. estimates of production losses have necessarily been developed on assumptions that bear substantially on predicting the actual impact of surface mining legislation. Principal among such considerations are the following:

1. *Losses are shortfalls from adjusted Project Independence projected gains.*—Losses are asserted as amounts by which coal production will fall short of projected increases in production called for by the Project Independence Report (Business as usual case as adjusted). Interior used a figure of 685 million tons as the amount of projected production in the first full year of implementation. This compares with 1974 production of 601 million tons and estimated 1975 production of 625 million tons. Project Independence projections are subject to other factors such as clean air restrictions, delivery system constraints, demand limitations and altered energy price projections. The estimates of production could fluctuate due to changes in these factors.

2. *Some parts of the estimates are based on relative 1974/1975 price levels of coal.*—A basic uncertainty in production levels results from uncertainty as to coal price levels and other energy price levels. Higher coal prices than the constant relative prices assumed in the Interior analysis could mean more coal production and lower relative coal prices could mean less production. This is particularly important since the estimates of increased costs resulting from the bill are in the range of $.50 to $1.50 per ton.

Weighted Average Price for surface mined coal f.o.b. mine averaged about $11/ton in 1974, and for all coal averaged about $15 per ton. Prices for long-term coal contracts have been rising although spot contracts are declining. If prices of competing energy sources increase, then over time of an unknown length, this suggests that cost increases can be passed on with smaller production losses than have been estimated.

3. *Losses are based on assumption of prevailing mining methods and technology.*—Technological improvements in both surface and underground mining methods could marginally diminish production losses over some period of time.

4. *Other supply and demand constraints may have a significant effect on increased coal production.*—Coal production is affected by the cumulative effects of supply and demand constraints such as transportation, manpower, availability of equipment, clean air and other environmental requirements, and coal user demand. Of these, the Clean Air Act and limited coal user demand may constitute more serious long run limitations on coal production than surface mining legislation.

5. *Time.*—In addition to the factors discussed above, the rate at which the productive system recovers and moves toward the Project Independence desired levels is dependent on the time which it will take for the industry to adjust and deal with the problem presented in the bill. This makes difficult any estimates of the coal industry's recuperative efforts beyond the first full year of complete implementation. In the short range (which could extend through the first 5 years), the industry's recuperative ability would be severely limited. But over time, the industry's ability to adopt to requirements of surface mining legislation would

improve. This is not to say that production will not increase but rather that the makeup tonnage will be difficult to achieve over the short run. It should also be noted that potential losses that could result from prohibitory provisions in the proposed legislation would reduce the production base rate for the longer range.

B. PROJECTED PRODUCTION LOSSES FROM H.R. 25 AS PASSED

Based on these assumptions, an assessment of the final language of H.R. 25 indicates estimated potential production loss figures of from 40 to 162 million tons for the first full year of implementation. These losses occur as a result of the bill's impact in three major areas for which the impacts are shown as follows:

	H.R. 25
a. Small mines	22–52
b. Steep slopes, siltation, and aquifer provisions	7–44
c. Alluvial valley floor provisions	11–66
Total	40–162

Additional unquantifiable losses could result from other provisions, including ambiguous terms, the designation of lands unsuitable for mining, and the surface owner protection provisions. A lack of technical manpower and equipment available and vagaries regarding permit application requirements may further hamper production.

The following methodology was employed in the analysis of the major categories of anticipated potential losses.

1. Small Mines: An examination of a large cross section of surface coal mines producing less than 50,000 tons per year and located principally in the East resulted in a determination that their ability to comply with the provisions of the bill relating to bonding and permit application was inherently limited since an initial outlay of from $6,000 to $12,000 would be required.

These mines being more sensitive to changes in costs of production than larger companies would be particularly impacted by the permit application requirements in Section 507 and the reclamation plan requirements in Section 508 of H.R. 25. Because of the lack of technical expertise available to the small mining companies, the requirements for collection of extensive baseline hydrologic data, for preparing detailed underground maps, for test boring and analysis of strata characteristics, for the preparation of detailed mining and reclamation plans, and for the assessment of mining impact upon the hydrologic balance would be beyond the capability of many of these small mines.

Susceptibility of small mines to increased costs is further aggravated by the permit bonding requirements in Sections 509, 515, and 519 of the bill. Although the minimum bonding requirement of $10,000 is in line with West Virginia's present requirement, it is higher than that in the other Appalachian States, the area containing the majority of the small mine operators. The requirement that a portion of the bond be retained for at least 5 full years after the last year of revegetation work could diminish the small operator's ability to obtain a bond and would tie up funds that might otherwise be invested in capital expenditures for further expansion of production.

Also impinging upon the small operator's mining costs would be the cost of additional equipment required to handle overburden in compliance with the steep slope requirements of Section 515(d). This increased cost would vary with the mode of equipment acquisition selected by the individual operator—outright purchase, time purchase or lease equipment—to suit the particular mining operation.

Control of siltation and water treatment requirements of Section 515 would increase operating costs for small mines. The additional diversion ditches, sediment control structures and water treatment facilities could inhibit production, particularly if large siltation structures must be constructed and then removed later without significantly decreasing water quality and significantly increasing sedimentation.

In some cases, the small operator's capacity to absorb the increased cost of production resulting from implementation of this bill is limited. Characteristically, the small mine is operated on small acreages not economical to mine by large companies. In some cases, the coal is owned by a large company which pays the small operator to mine at a fixed contract fee per ton on limited acreages that the company would not mine itself. The fixed fee arrangement limits the capability of the operator to respond to cost increases because all operating expenses, including mine payroll, is paid from this fee.

In deriving these potential losses, personnel from the Federal Energy Administration examined seven Appalachian States where the greatest impact would occur. The loss figures came from three sources: (1) State Agencies—Offices of Mined Land Reclamation; (2) State Associations—Mined Land Reclamation Associations; (3) Mining companies—reliable corporations whose information could be substantiated by No. 1 and No. 2 above. The figures resulting from this survey are in the following table. The estimated possible production loss is approximately 52 million tons. It was estimated by Bureau of Mines and F.E.A. personnel that under favorable interpretations by the regulatory authorities that as much as 60 percent (30 million tons) of this estimate could be produced without loss. Therefore, the range of losses derived for small mines was put at 22–52 million tons. This loss is approximately 37–87 percent of the expected production (60 million tons) during the first full year.

2. It is estimated that the losses from the category of steep slopes, siltation and aquifers would range from 7–44 million tons. This figure can be separated as follows: Steep slopes (7–25 million tons), aquifers (0–9 million tons) and siltation (0–10 million tons).

(i) In estimating potential production losses from steep slope restrictions, the total amount of surface projected production to be derived from slopes greater than 20° was examined. This figure was conservatively estimated to be 110 million tons for the first full year of implementation and was arrived at by projecting the production from steep slopes derived by the Council on Environmental Quality in 1973. By obtaining estimates of steep slope production from small mines it was possible to separate out the production on steep slopes from mines producing more than 50,000 tons per year Therefore, estimated losses from this category are only from larger mines which will have a total projected production of approximately 68 million tons in the full year. The estimated loss of 7–25 million tons is approximately 6–23 percent of the total estimated steep slope production (110 million tons) and approximately 10 to 35 percent of projected steep slope production from mines larger than 50,000 tons per year (68 million tons).

The provisions in H.R. 25 relating to steep slopes require all highwalls to be completely eliminated and makes no allowance for terracing or placement of spoil on the downslope, other than for the first cut. Federal Energy Administration personnel examined various Eastern States where steep slope mining is prominent and solicited opinions from the State regulatory authority Agencies and reclamation organizations of what the expected effect of such provisions could be.

The Bureau of Mines personnel also examined production trends in several Appalachian States which have strong surface mining laws relating to steep slope mining. Results from this examination indicated decreases in production, after enactment of these laws, ranging from approximately 20 to 30 percent. These results supported the information obtained from the States by Federal Energy Administration personnel. Based on sound engineering judgment and the experience of our personnel familiar with mining in Appalachia, and taking into consideration the above factors, an estimate of the possible losses, resulting from steep slope mining at mines producing more than 50,000 tons per year, of approximately 10 to 35 percent was derived (7–25 million tons). This loss can be attributed to delays in equipment procurement due to influx of demand for equipment necessary for block-cut or haul-back techniques of overburden handling, and time involved in obtaining and training additional personnel necessary for operating this additional equipment. Also attributable are reduced productivity inherent in managing movement of additional on site equipment used in the overburden handling techniques that would be required on these steep slope operations.

(ii) In assessing possible production losses from aquifer protection provisions, of the projected production of 90 million tons its was estimated that at worst up to 9 million tons or 10 percent of the projected production could be abandoned because of the inability of some operators to affirmatively demonstrate that the recharge capacity of the minesite could be completely restored to premining conditions.

Section 515(b)(10)(D) specifically states that the operator must restore the "recharge cpacity of the mined area . . .," in addition to minimizing disturbances to the hydrologic balance at the minesite and associated offsite areas and to the quantity and quality of associated water. The ground water hydrology of a coal-bearing area may be disrupted whenever coal is mined either by underground or surface methods. Whenever the coalbed and associated shales that

may serve as an impenetrable barrier to ground water are disrupted, the ground water hydrology is affected by allowing the water to drain to lower strata. Also where the coalbed serves as an aquifer, interruptions of the aquifer in sufficient extent may lower wells dependent upon such sources for supply. In addition, water quality may be changed if backfill material contains significant amounts of soluble minerals not present in the aquifer. Riparian rights as well as State water pollution regulations may affect reserves when major aquifers could be affected by mining operations. Water rights on a property may be separate and distinct from the mineral or surface estate and the requirement of obtaining the consent of water rights owners may further reinforce a tendency toward strict interpretation of hydrologic features of the bill.

Using the above as a guideline experienced Bureau of Mines and Federal Energy Administration personnel judged to the best of their capabilities that as much as 10 percent (approximately 9 million tons) of projected production from areas other than those considered under other categories of losses could be lost. This amount would depend greatly on the interpretation of the regulatory authorities and the courts. Under favorable interpretations it is estimated that there may be no effect on production in this area.

(iii) Losses due to siltation requirements could range from 0–10 milion tons during the first year of implementation. Again, this estimate was based on engineering judgment by Bureau of Mines and F.E.A. personnel. Under provisions of H.R. 25 in Section 515(b)(10)(B) operators would be required to "prevent, to the extent possible, additional contributions of suspended solids to stream flow or runoff outside the permit area above natural levels under seasonal flow conditions." It could be difficult, if not impossible, for an operator to "affirmatively demonstrate" that he could comply with this provision because of the uncertainty and inability to accurately measure natural runoff levels under seasonal flow conditions. Even though an operator might obtain an average measurement of such flow prior to mining, the year he is actually mining may be a year of unusually high natural runoff and sedimentary flow. If this were to be the case, it would be difficult for an operator to show that high sedimentation was due to natural causes and not due to the mining operations. In addition, some production could be lost because of the inability of some operators to economically construct the additional diversion ditches, impoundment structures and water treatment facilities which would be required to effectively control siltation and acid mine drainage

Section 515(b)(10)(C) requires the removal of large siltation structures after revegetation and stabilization. While this is possible in many cases, frequently large siltation structures are intended to be of a permanent nature and removal would cause sudden surges of sedimentation which would be unacceptable. Additionally, sedimentation would be produced from the disposal area in which the materials forming the removed structure and impounded silt are deposited and would continue until the surface could be sufficiently stabilized by a vegetative cover. Such siltation could continue for some time due to the structural instability of the classified clayey fractions of the silt removed from behind such impounding structures.

Alluvial valley floors: Losses resulting from provisions relating to alluvial valley floors would range from 11 million to 66 million tons during the first full year of implementation. To arrive at a possible loss of 66 million tons, surface mine production data were collected for 1974 production west of the 100th meridian west longitude. This amounted to 57 million tons. Based on a mine-by-mine analysis it was judged that approximately 38 million tons or approximately 68 percent of this production was mined from alluvial valley floors as defined in the bill or was being mined in areas that could adversely affect alluvial valley floors. By projecting the ratio of 1974 production from such areas to projected production for the first full year of implementation, a resulting potential loss of approximately 66 million tons was derived. Production forecasts, obtained from contracts and company reports, forecast 83 million tons of strip coal from the Northern Great Plains by 1977, of which 40 million tons will be be from 13 mines in Wyoming, 36 million tons from 5 mines in Montana, and 8 million tons from 5 mines in North Dakota. Conservative forecasts in other States would bring total projected production up to approximately 95 million tons. Arizona was excluded because of little or no effect on alluvial valley floors.

The possible minimum loss figure of 11 million tons attributable to the alluvial valley floor provision was determined by examination of actual mining operations and application of three key factors in the language of the Act: (1) the area

that is now under intensive agricultural usage (including farming and hay meadows) (2) the amount of undeveloped rangeland and (3) potential farming and ranching as defined in H.R. 25. Each of these factors involves some uncertainty and cannot be clearly determined on a national basis , but is based on our assessment and our best professional judgment.

Determination of the coal production affected by the alluvial valley floor provisions of the bill is subject to many interpretations. From an engineering viewpoint, there are contained within the language many ambiguous or difficult-to-define terms such as "significant," "substantial," and "potential," and it is impossible to develop a precise minimum figure. One figure, the lowest, is the coal production lost if only that coal actually under the alluvial valleys which have been developed for agriculture production is used. If the proposed legislation were enacted such mining operations would stop, and production, if it were to continue, would have to be shifted to areas adjacent to the alluvial valleys. Some present mining operations have no such areas to mine and all other mines were they to be required to change the area of production will be faced with radical changes and production problems. These will include a new plan for mining, in many cases a new permit application, increased stripping ratios, and different, larger, or accelerated equipment requirements. If the mines stopped by these provisions were to be removed from production for the first year (not a remote possibility) the minimum effect on production could be 24 million tons. Assuming that some of this production was maintained at mines having suitable reserves and at a reduced rate, it is estimated 11 million tons of production would be lost.

Production would not be entirely lost in some cases if some mines were able to move from the alluvial valley floor to upper benches. However, this would require a major equipment expansion due to the increased cover. Many of the present mines do not have the larger equipment necessary to handle the thicker overburden, and the long delay (5 years) in receiving such equipment, would cause insurmountable production delays and outright losses.

A restrictive interpretation of the legislative language would decrease the amount of coal production dramatically. The hydrologic function of alluvial valleys is dependent on the tributary streams and ground water draining into the valley. Alluvial valley floors are not only dependent on major drainages with perennial stream flows but on small intermittent tributaries. These include the canyons and the coulees that extend into the mining areas.

It is these areas that will effect the hydrological function of the valley floor. When such streams and their water sheds are disturbed by mining, the runoff to the alluvial valleys is affected and consequently the hydrologic function of the valley, which is prohibited in the statutory language. Using this criteria much of the mining and reserves west of the 100th meridian would be impacted. Enclosed is a table showing 1974 total production and estimated production on or affecting alluvial valley floors.

4. Unquantifiable losses.

(a) *Designation of Areas Unsuitable for Surface Coal Mining.*—Although not presently quantifiable due to the lack of knowledge about the propensity of the respective authorities enumerated in Section 522 to enforce the provisions of that Section, it must be recognized that possible losses of production could occur. While current operations would not be affected, long term production could be affected should strippable coal reserve areas readily accessible to existing transportation facilities be designated unsuitable for surface coal mining. Such areas could include those areas in the East with growing suburban areas where land use planning would affect coal reserves, fragile lands or aquifer containing areas and recharge areas in the West, and Midwest, and slip-prone steep slopes in the Appalachian States.

(b) *Surface Owner Protection.*—The provisions of Section 714 that apply to privately owned surface areas overlying Federal coal deposits would not have an immediate effect on production from existing operations. The effect of the application of these provisions, however, in the long term would be to inhibit production from such lands should agreement not be reached to adequately compensate the surface owner for his losses. The inclination for a surface owner to accept a maximum allowable compensation of $100 per acre would be minimal.

Therefore, the productivity of public coal reserves under private surface ownership could be seriously curtailed. Future revenue to the State and Federal Government from royalties derived from production from such reserves would be reduced accordingly as production of such coal so situated declines. Revenue from

increased taxes would be required to support State and Federal programs presently supported by royalties paid by operators mining these reserves.

(c) *Permit application requirements.*—The inhibiting effect of extensive permit application requirements on operators that produce more than 50,000 tons annually must be recognized also as a potential source of production loss. Permit application submission, review and approval patterns would be disrupted with consequent delays in production. Acquisition of baseline data, acquisition and analysis of test borings, development of cross sections and other subsurface data, and development of hydrologic data required for the permit application and for development of the reclamation plan require time that delays initiation of the mining operation.

Evidence can be seen further in the effects on production of strong surface mining laws by examining several States which have passed such Acts. Taken as examples are Ohio, West Virginia, and Tennessee, all of which have comparative strong surface mining legislation which have been in effect for several years.

The Ohio reclamation law, which was revised and put into effect in April 1972, appears to have had a severe effect upon surface production. In the 10 years preceding the enactment of the Ohio legislation, production from surface mining increased every year. Production for the year preceding the effective date of the legislation was approximately 38.6 million tons. Production then gradually dropped to 29.6 million tons in 1973. This reflects a decrease in production of approximately 23 percent.

West Virginia's law was effective as of March 1971 at which time surface production since 1961 had shown gradual increases from 8.5 million tons up to 27.7 million tons for the year preceding the effective date of enactment. Production then dropped to 19.9 million tons in 1973 which is a decrease of approximately 28 percent.

Production in Tennessee also gradually increased up to 5.7 million tons in the year preceding the State's reclamation law which became effective in March 1972. Production then dropped off to an estimated 4.3 million tons in 1974. This is a decrease of approximately 25 percent.

While it cannot be stated with certainty that production decreases in these States were due entirely to the impact of the individual reclamation acts, it is clear that these laws did have a severe effect.

It should also be pointed out that while these State laws are very strong and in many aspects are up to or near the standards of H.R. 25, they are also less restrictive in some areas. For instance, Ohio has a variance which allows terracing; West Virginia does not require elimination of highwalls in all cases and in none of these laws are there the stringent permit application requirements and preplanning which are required in H.R. 25 which we feel could have a devastating effect n small mines.

Pennsylvania, while it is considered as having a relatively strong law, as close to the standards of H.R. 25 as Ohio, West Virginia, and Tennessee, does not have the relatively significant portion of steep slopes present in the other three States. In addition, the provisions of the 1971 Pennsylvania law relating to steep slopes do not seem to be much more stringent than in previous Pennsylvania legislation.

1974 COAL PRODUCTION AND ESTIMATED ALLUVIAL VALLEY PRODUCTION BASED ON INTERPRETATION OF LANGUAGE IN H.R. 25

[Millions tons]

State company	Mine	Estimated coal production	Estimated strip coal production	Estimated production alluvial valley [1]
Colorado [2]		7.0	3.7	3.4
Annex Coal Co	Annex No. 2 strip	X	X	----
Cannon Coal Corp	Corley Strip	X	X	----
Peabody Coal Co	Nucla	X	X	----
Mid-Continent Coal & Coke Co	Coal Basin Strip	X	X	----
Energy Fuels Co	Energy No. 1	X	X	X
Do	Energy No. 2	X	X	X
Peabody Coal Co	Seneca	X	X	X
The Pittsburgh & Midway Coal Mining Co	Edna Strip	X	X	X
Kerr Coal Co	Marr No. 1	X	X	----
Montana		14.1	13.6	10.1
Decker Coal Co	Decker	X	X	X
Divide Coal Mining Co	Storm King	X	X	----
P M Coal Co	P M Strip	X	X	----
Square Deal Coal Co	Square Deal	X	X	----
John H. Schoonover	Coal Creek Strip	X	X	----
Knife River Coal Co	Savage	X	X	----
Western Energy Co	Rosebud No. 6	X	X	----
Peabody Coal Co	Big Sky	X	X	X
Westmoreland	Sarpy Creek	X	X	X
New Mexico		9.7	8.8	7.4
The Pittsburgh & Midway Coal Mining Co	McKinley	X	X	X
Sundance Coal Co	Sundance	X	X	----
Western Coal Co	San Juan	X	X	----
Utah International, Inc	Navajo	X	X	
Kaiser Steel Corp	West York Canyon Strip	X	X	----
North Dakota		7.4	7.4	3.2
Virgil Smith	Arrowhead	X	X	----
Bardid Division, NI. Industries, Inc	Smith-Ullman	X	X	----
Knife River Coal Mining Co	Gascoyne	X	X	X
Baukol-Noonan, Inc	Larson (Noonan)	X	X	X
Sprecher Coal Mining	Sprecher	X	X	----
Consolidation Coal Co	Glenharold	X	X	----
Knife River Mining Co	Beulah	X	X	X
The North American Coal Corp	Indian Head	X	X	X
Baukol-Noonan, Inc	Center	X	X	----
Dickinson Coal Mining Co	Binek Strip	X	X	----
Husky Industries	Husky Strip	X	X	----
Consolidation Coal Co	Velva	X	X	----
GEO Resources Inc	Nelson Strip	X	X	----
Utah		6.0	0	0
Washington		3.9	3.9	3.9
Black Prince Coal Co	Black Prince Strip	X	X	X
Washington Irrigation & Development Co	Centralia Strip	X	X	X
Wyoming		20.6	19.9	10.8
Amax Coal Co	Belle Ayr	X	X	X
Wyodak Resources Development Corp	Wyodak	X	X	X
Arch Minerals Corp	Seminoe No. 1	X	X	X
Do	Seminoe No. 2	X	X	X
Rosebud Coal Sales Co	Rosebud No. 4–A Strip	X	X	----
Resource Exploration & Mining	Rimrock Nos. 1 and 2	X	X	----
Best Coal Co	East Antelope Strip	X	X	----
Pacific Power & Light Co	Dave Johnston	X	X	----
The Kemmerer Coal Co	Elkol	X	X	----
Do	Sorenson	X	X	----
Big Horn Coal Co	Big Horn	X	X	X
Welch Coal Co	Welch	X	X	----
Pacific Power & Light Co	Jim Bridger	X	X	----
Total		68.7	57.3	38.8

[1] Estimated production based upon H.R. 25 as amended. A strict interpretation with burden of proof upon the mining company that no alluvial valley sediments nor the surface or underground water into those alluvial sediments will be adversely affected.

[2] Mining on dip slopes are interpreted to adversely affect the alluvial valley sediments.

Appendix X

Senate Staff Analysis of the Administration's Justification of the Veto of H.R. 25

Senate Staff Analysis [1]

Senate Staff Analysis of the Administration's Justification of the Veto of H.R. 25

SUMMARY

When President Ford vetoed H.R. 25 on May 20 he claimed that it would restrict coal production, increase our dependence on Mid East oil, raise consumer prices and increase unemployment.

Analysis of the materials justifying this move prepared by the Administration after the President's veto and testimony at the June 3 hearing on the veto message revealed that these claims are false. The key points of this analysis are summarized as follows:

Federal Energy Administration and the Department of the Interior would recommend a veto of the President's own bill. They have apparently accepted the National Coal Association's position that we should rely on state laws for surface mining control. However, in the past enforcement of state laws has been notoriously lax, and in any event, they do not regulate the surface mining of 40% of the nation's coal, which is owned by the Federal government;

Production loss estimates are based on highly unlikely and admittedly unrealistic interpretations of H.R. 25. All other estimates, costs, job losses, oil imports, are based on these faulty production loss estimates; and

Despite widespread coal and utility industry propaganda to the contrary—propaganda echoed by the President—H.R. 25 will not cause any significant increase in electric bills.

At the June 3 hearings the Administration admitted that Congressional estimates of the cost of reclamation (including the reclamation fee) were correct. These costs will average about $1.00 per ton.

In view of the fact that the average price of coal has doubled in the last 18 months, and coal industry profits have risen even faster, there is no reason why these costs should not be absorbed.

But even if the coal and utility industries insist on passing all the cost on the consumer, it will only be approximately 35¢ per month for the average user of surface-mined coal-fired electricity. And this is less than 30% of electricity.

The Administration refuses to assume that the coal industry can adjust by first full year of implementation (1978), despite a three year phase-in period and the vast extent of U.S. coal reserves. This assumption runs counter to Administration testimony that small mines go in and out of production so rapidly that they were unable to furnish the Congress with a meaningful list of mines allegedly impacted by the bill. It also ignores the fact that there is considerable surge capacity within the industry.

All Administration feared losses—including jobs—are only during a three or four year period beginning in *1978*, which is the first possible full year of implementation, and not 1977, as used by the Administration: According to FEA, the 1977 date used in May of 1975 assumed enactment in January 1975.

The Administration does not indicate in its methodology any netting out of production losses which overlap, as between small or steep slope mines, for example.

The Administration denies that additional jobs will be created by the reclamation programs provided in H.R. 25. The President claimed that enactment of H.R. 25 could result in loss of between 9,000 and 36,000 jobs. The Administration witnesses stated that a substantial portion of this estimate was based on studies done by Dr. William H. Miernyk, of West Virginia University. But, Dr. Miernyk, the only non-government expert cited by the Administration, has totally repudiated the Administration's claims of job losses. Dr. Miernyk has stated that H.R. 25 will not lead to any loss of jobs whatsoever. Furthermore, when compared to the unemployment projected under the President's energy progarm—600,000—any impact of H.R. 25 pales into insignificance.

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[1] Source: "Surface mining veto justification briefing," Hearing, House Committee on Interior and Insular Affairs, June 3, 1975: U.S. Cong., 94th, 1st Sess., H. Serial No. 94-23, pp. 158-167.

The President focused heavily in his veto message on the notion that H.R. 25 would increase U.S. dependence on Mid East oil. Yet production losses due to the bill—if any—will affect utilities. These burn imported residual oil from Venezuela and the Caribbean—not Mid East crude.

DETAILED ANALYSIS

Total production loss estimates

The production losses projected by the Administration range from 6–24 percent of a projected total production in 1977 of 685 million tons. In one instance they estimate that 350 million tons of this is expected to be stripped; on another occasion, the estimate is 330 million. No explanation is given for this discrepancy. According to the Administration, those losses will occur because of provisions in the bill dealing with small mines, steep slopes, siltation, aquifers and alluvial valley floors. The Administration claims there is no doublecounting between estimated production losses in each category.

One is led initially to question the Administration's figures for a number of reasons. 1. The projected production figure they use is 685 million tons, which is 70 million tons lower than the base case, business-as-usual projection made in Project Independence, but no explanation is given for the discrepancy. 2. The projected losses are for 1977, while the first full year of implementation cannot possibly be until 1978, and more likely not until 1979, since there is a 36 month phase-in period for full implementation of the bill. Furthermore, losses are assumed to continue only for three years, and to disappear thereafter. Yet no estimates are given for losses in 1978–82, 3. No explanation has ever been given of the methodology used to avoid doublecounting production loss estimates between small mines and mines on steep slopes, although most small mines are on steep slopes; or between production losses projected due to protection of aquifers and alluvial valley floors, although again there is considerable overlap between the two.

4. The Administration's extimates are based on the assumption that through 1980, there will be no relocation of mines and that production lost because mining at one location becomes too costly or is prohibited under the Act, will not be replaced by production at a mine in a site more suitable to mining. (In earlier estimates, however, they assumed 20% of last surface production would be made up in deep mines.)

They further assume that no excess capacity will exist in the industry which could be used to maintain production by additional shifts or increasing working hours. Yet such capacity exists. As a case in point, prior to the national coal strikes called by the United Mine Workers when their contracts expire, production has increased markedly as consumers stockpile coal. For example, production increased approximately 10 million tons in October, 1974 over midsummer levels in anticipation of the November 1974 strike. In 1971, the same phenomenon was observed. It is thus unrealistic to assume that no production lost because of H.R. 25 could be replaced for three years.

5. The broad range of the Administration's loss estimates indicates a significant lack of certainty on the part of those making the estimates. The discrepancy of 400 percent between the low and high cost ends of the production loss estimates implies a methodology for quantification which is at best exceedingly imprecise. And, as was brought out in hearings before the House and Senate Interior Committees, such was indeed the case. The upper range of losses in particular is predicated on highly unlikely and admittedly totally unreasonable interpretations of the bill's provisions.

While the total impact of the bill is derived from the production loss estimates, these estimates themselves are based on the anticipated impact of certain provisions of the bill, listed above. Yet at no time has the Administration been willing (or able) to relate specific requirements of the bill to specific anticipated production losses. One would therefore infer that the estimates are not based on careful analysis.

Production losses from small mines

The Administration contends that implementation of H.R. 25 will reduce production from small mines by 40–100% in 1977 (although actually full implementation would not occur until 1 or 2 years later). They give no explanation of *why* this range was chosen or to what provision of the bill these losses were attributable. Nor, apparently, do their projections take account of the long and continuing decline in small mines' share of total production, which would

reduce anticipated losses in this category in 1977. Again, these loss estimates, which range from 22–52 million tons, are predicated on the assumption that none of this production will be otherwise replaced. The Congress was initially informed that these estimates were based on a broad cross sectional analysis of small mines. Yet, further Congressional inquiry into the methodology used to derive these figures eventually resulted in the admission that a few mine operators, mine operator associations and inspectors in 6 states were asked by telephone what impact they thought the bill would have on small mines. The production loss estimates are apparently actually based on the casual responses to these inquiries.

Production losses from steep slopes

Although a large percent of small mines are located on steep slopes, the Administration's methodology does not net out the overlap between the two in making its production loss estimates. It is therefore virtually impossible to ascribe much validity to either figure. The Administration ascribes production losses on steep slopes to "some loss of productivity" ranging from 6–23%, but the reasons why a loss of productivity is assumed are never stated. Furthermore, numerous studies have been made available to the Congress which indicate that ongoing mining operations in W. Virginia, Pennsylvania and Kentucky, which are already meeting the steep slope reclamation standards of H.R. 25, have actually increased their productivity, largely by minimizing earth moving requirements. The Administration's analysis apparently took no notice of such studies. Finally, the Administration's estimates assume no relocation of mines to more suitable sites. Yet, when asked to furnish Congress with a list of small and steep slope mines, the Bureau of Mines said such mines were constantly relocating and shifting their operations, and it was impossible to maintain an up-to-date list of them.

Siltation

The Administration estimates that up to 10 million tons could be lost because of siltation control requirements. However, since such provisions are already incorporated in most state laws, it is difficult to comprehend why production losses should be anticipated, if H.R. 25 is implemented, and the Administration does not elucidate.

They do say some areas perhaps could not be mined unless permanent siltation structures were built to prevent post mining sedimentation. This ignores the requirement in the bill that all disturbed areas must be stabilized and revegetated after mining, thus negating the need for retention of siltation structures. However, given their assumption that mine operations will not relocate elsewhere, this might contribute to the estimated production loss. But again, no explanation is given.

Aquifers

As in the case of small and steep slope mines, the Administration's methodology does not provide for netting out of their production loss estimates related to protection of aquifers and protection of alluvial valley floors, which contain aquifers. They estimate that up to 9 million tons of planned production near an aquifer-fed water source could be abandoned under extreme interpretations of the bill. However, the bill focuses on protecting the recharge capacity of aquifers and not aquifer-fed waters. So the Administration's estimate would appear to be based on a misinterpretation of the requirements of the bill.

Production losses on alluvial valley floors

Given the definition of alluvial valley floors in the present bill, the Department of the Interior estimates that no more than 2.7 percent of the land in the Powder River Basin (the major Western coal area) would be affected by the bill. Given the vast amounts of coal west of the 100th meridian, the impacted area is therefore relatively insignificant.

In contrast, the Administration's estimates of potential coal losses on alluvial valley floors ranges from 11–66 million tons. These estimates, however, are based on a number of fallacies and misinterpretations of the bill. For example, the definition of alluvial valley floors in the bill specifically and explicitly excludes undeveloped rangelands. Yet the Administration includes undeveloped rangelands as part of the area where they consider coal production might be inhibited by implementation of H.R. 25.

In addition, although the present bill contains no ban on mining on alluvial valley floors, the Administration's maximum estimate of production losses under

the bill (66 million tons) is identical to their estimate of production losses if mining were banned on alluvial valley floors. Thus, presented with two entirely different sets of parameters and assumptions, they did not change their estimates of potential production losses.

Finally, members of Congress have had discussions with the Administration about the methodology by which they arrived at their production loss estimates for alluvial valley floors. Representatives of the Administration explained that their estimates did not represent a range of potential or even probable losses, but at times were based on assumptions that are entirely unrealistic.

For example, the alluvial valley floors covered by the bill are those where "farming can be practiced in the form of irrigated, flood irrigated or naturally subirrigated hay meadows or other crop lands." The Administration admitted that its high estimates were based on an assumption that the Courts might interpret the word "irrigated," to mean that if someone could run a garden hose from New Jersey to a Western alluvial valley, it would make the area subject to the alluvial valley requirements of the bill. The high side of the Administration's projections therefore assume that all alluvial valley floors are covered by the special provisions of H.R. 25. It was further explained that, as long as any one person could so interpret a provision, that interpretation however improbable, was incorporated into the maximum estimates of production losses. It is interesting that this discussion was almost immediately preceded by insistence on the part of the Administration that practical economics should be considered in all interpretations of the bill.

FURTHER LOSS ESTIMATES

It is obvious from the foregoing that the Administration's estimates of production losses attributable to H.R. 25 are generally unfounded and highly questionable. It is, in fact, more likely given the long phase-in period of the bill and the vast extent of U.S. coal reserves, that no production losses will occur. Yet the Administration uses these doubtful estimates as the cornerstone for all other Administration estimates of the impact of the bill emphasizing at all times the maximum adverse potential effects of implementing H.R. 25. From these dubious production losses they extrapolate employment losses, increased oil imports, fuel costs and consumer costs, and coal reserve losses.

Employment impacts

The Administration's estimates of the employment impacts of H.R. 25 are extrapolated directly from their highly dubious estimates of losses in coal production. These impacts would occur, if at all, when the production losses, if any, took place—in the first full year of implementation of the Act. The first full year of implementation is not 1975; it is 1978.

The Administration's estimates are, at the low end, a direct job loss of 5,000 resulting from a production loss of 40 million tons.

The maximum production loss, 162 million tons, translates, in Administration methodology, into a direct job loss of 20,000.

In addition to this, the Administration *assumes* eight non-mining jobs will be lost for each ten mine job losses. This assumption is drawn from the work of Dr. William Miernyck who was cited by the Administration as an expert on coal input-output analysis. Dr. Miernyck has flatly stated that H.R. 25 will not cause any job losses whatever. Nevertheless, using these figures the Administration estimates a total employment impact of 9,000 to a maximum of 36,000 for the most extreme production loss estimate. Also, in fact, even without H.R. 25, they project a decline of some 4,000 surface mines by 1977 despite increased production.

Despite earlier statements by leading spokesmen, the Administration is not willing to admit that employment will increase as a result of H.R. 25 because of increased requirements for reclamation. In fact, the incredible claim is made that, because abandoned mine reclamation would be financed from a tax on production, a job would be lost elsewhere in the economy for each job created by the program. This view, of course, implies a total uselessness for any tax-supported public works project from the point of view of employment. Using this logic, one would also be forced to claim that the building of U.S. Interstate Highway System did not constitute a stimulus to employment. Yet, the President has recently supported a $2 million public service job program.

By 1978, the earliest possible full year of implementation of the bill, the civilian work force will be well over 100 million. The employment impacts which the Administration claims will result from H.R. 25, if they materialize at all, will constitute between .01 and .04 percent—one and four *one hundredths* of a percent

of the 1978 work force. The Administration's concern over very uncertain prospects for a very small level of unemployment in 1978 are scarcely matched by its concern for the staggering unemployment actually being experienced in 1975 and which is forecast for 1976. The Administration's energy tariff and price decontrol proposals attempt to ration energy supplies by increasing energy prices. These price increases are inflationary, and they pose a severe threat to recovery from the current recession. Eric Herr, of Data Resources, Incorporated, a firm specializing in economic analysis and forecasting which is an important supplier of economic information and analysis for the FEA, testified before the Senate Interior Committee on February 12, that "assuming that the Federal Reserve does not fully accommodate the President's program. but rather increases the money supply at only a six percent to eight percent annual rate, the damage to the economy (from the President's program) would be substantial. . . . The unemployment rate would be raised by 0.3 percentage points by the end of this year (1975) and by 0.7 percentage points in 1976, increasing unemployment in the year 1977 by 660,000 persons."

The Administration's deep concern over the possible loss of jobs in 1978 is totally hypocritical when measured against its insistence on the implementation of a program in 1975 which is virtually certain to guarantee unemployment in 1975 and 1976 for hundreds of thousands more Americans.

Only a day after the hearings at which Administration witnesses expressed alarm over the alleged 9,000 to 36,000 job loss impact in 1978 of H.R. 25, an FEA spokesman was quoted saying that the impact of 7,000 to 14,000 persons unemployed in 1975 and 1976 as a result of the Administration's energy program would be "insignificant." (The Administration maintains that these "insignificant" figures are the proper measure of increased unemployment from the energy tax, tariff and price decontrol proposals of the President.)

Perhaps the final and most obvious irony of the Administration's contentions concerning the employment impacts of H.R. 25 is the fact that the UMW and the AFL-CIO—the labor unions which represent U.S. surface miners—have expressed formal support for the bill, and have urged its passage. (The AFL-CIO is in strong opposition to the President's energy pricing proposals.)

Oil imports

The most important chain of reasoning leading to the veto of H.R. 25—in the view of the Administration—is the contention that

(1) coal production will be lost as a result from provisions of this legislation; and

(2) that this loss will require increased oil imports and higher dependence on insecure Mideastern producers.

There is no claim that coal production losses will persist—only that they will characterize the first three-to-four years of implementation of the Act. Thus the time interval of potential concern—and it is the only period for which there could be concern—is the period from 1978 to 1980. This year, 1975, and in 1976, and in 1977, during the phase-in period for H.R. 25, the legislation can have no significant negative effect on domestic coal production. Therefore there can be no short term increase in oil imports during 1975–1977 as a result of H.R. 25 either. The nation has over 30 months to prepare for the impact of the bill.

If it is granted for the sake of argument that surface coal production losses will in fact occur in the period beyond 1977—and this is far from certain—how will these losses be made up? A March 25 memo, made available to Congressional staff by Thomas V. Falkie, Director of the Bureau of Mines, estimated that 20 percent of production losses attributable to H.R. 25 would be made up from increased production in underground mines. By the time Mr. Zarb was ready to testify before the Senate and House Interior Committees, the Administration had changed its mind and was maintaining that none of the alleged lost production from surface mines would be made up in underground mines or in other surface mines.

However, this is precisely what will happen if there is a demand for coal and a coal mine is shut down somewhere for any reason. Operators of other mines will attempt to capture this business—because it is a profitable business—by adding additional shifts, extending shifts, etc. These other mines will be able to produce the extra coal to the extent that it is available and to the extent they can anticipate the unsupplied demand. In the case of the alleged potential impact of H.R. 25, both conditions would seem to be filled.

But suppose—for the sake of argument—that some switching to oil does take place. The U.S. will then import more residual fuel oil. The Administration's

pre-veto analysis did not distinguish between crude oil and residual fuel oil. In fact it is the latter which is burned in electric utilities and most of this fuel is currently imported. Only 7–9 percent of the output of U.S. refineries is residual fuel oil. Imported residual fuel oil comes overwhelmingly from the Caribbean and from Venezuela. It is based primarily on Venezuelan and Nigerian crude oil. Neither of these countries has expressed any interest in embargoing the United States. In fact, during the 1973–74 embargo, residual fuel imports held to a curve which tracked 1972 and 1973 figures for comparable months—allowing for conservation and warmer weather during the 1973–74 winter. No embargo-induced dip is apparent for residual fuel imports, such as was evident in the case of crude oil imports. There is a very good reason for this: we import a substantial amount of crude oil from the Arabs, but almost no residual fuel oil.

According to the Petroleum Industry Research Foundation, during the post-embargo June–October, 1974 period the U.S. imported less than 2 percent of its residual fuel oil from Arab countries. Over 86 percent came from the Caribbean and Latin America.

U.S. RESIDUAL FUEL IMPORTS, JUNE–OCTOBER PERIOD

	1973	1974
Origin:		
Arab	29.6	20.0
Other Eastern Hemisphere	200.9	95.3
Canada	114.3	51.8
Caribbean and Latin America	1,174.4	1,075.2
Total	1,519.7	1,242.3

Source: Petroleum Industry Research Foundation.

The danger the U.S. faces from an Arab embargo is an interruption in crude oil imports for U.S. refineries. The principal refined products affected by such an embargo are the principal products of U.S. refineries—motor gasoline and distillate fuel oil. Residual fuel oil availability would be only very weakly affected by even the most successful future embargo.

Thus the Administration's concern over the alleged impact of H.R. 25 in increasing U.S. dependence on foreign oil can not relate to a concern over insecurity supply in the event on an embargo. The utility industry will not be significantly affected by a reduction in crude oil imports from Arab nations.

The only concern of the utilities is the price of their fuel. This cannot be a great Administration concern, however, in view of its proposal to add at least $1.80 per barrel to the price of imported refined petroleum products. Translated to the Btu equivalent in coal utility boiler fuel, this would represent an increase in coal prices of almost $6.30 per ton—an impact which is at least six times any conceivable impact of the reclamation fees and reclamation costs associated with H.R. 25.

Impact on electric utility bills

The Surface Mining Control and Reclamation Act of 1975—H.R. 25—will cause only a very slight increase in the price of electricity generated from coal. According to the Edison Electric Institute, the average consumer uses less than 700 kilowatt hours per month. The increased electricity costs due to the reclamation of strip-mined land will amount to one to two percent—less than 35¢ per month to the bill of residential consumers whose electricity depends on surface-mined coal. For electricity generated using coal mined underground, the increase in price will be negligible. Costs for power generated by other fuels will not change.

Generally speaking an increase in the price of coal of $1.00 per ton translates into an increase of one twentieth of a cent—0.05¢—per kilowatt hour of electricity. On the average, residential consumers in the U.S. now pay approximately 3.0¢ per kilowatt hour for electricity, according to recent reports of the Edison Electric Institute.

H.R. 25 will add at most $1.00, on the average, to the price of surface-mined coal. This includes the reclamation fee—much less actually for lignite—and operators may have to pay up to $0.50 per ton on new production to cover costs of reclaiming land damaged by their own operations. Administrative costs will add a few pennies more to the price per ton.

Surface-mined coal constitutes approximately one-half of U.S. coal production. The fee assessed by H.R. 25 on the remaining underground production is $0.15 per ton. This fee will have a negligible effect on the price of electricity produced using deep-mined coal.

Thus the cost impact of reclaiming land damaged by strip-mining in the past and to restore the land to be disturbed to mine the coal supplies required for the future is approximately a nickel for every 100 kilowatt hours of electricity, less than 35¢ per month for the average user and approximately $1.30 per month for an all-electric home.

Coal company profits

Electricity rates and coal prices have soared over the past year as energy prices were pulled up by the steep rise in the price of imported and domestic crude oil. These increases have hit consumers hard and have swollen the profits of coal companies. According to data compiled by the Congressional Research Service, major coal companies have seen their earnings increase by over a thousand percent in 1974.

COAL COMPANY EARNINGS

[Dollar amounts in millions]

	3d quarter 1973	3d quarter 1974	Increase 1973–74	Percent increase
Consolidation coal	$0.2	$15.0	$14.8	7,850
Island Creek Coal	—.9	35.2	36.1	(2)
Pittston	[1] 3.1	27.5	24.4	790
Westmoreland Coal	1.0	12.8	11.8	1,240

[1] Loss.
[2] Infinite.

Source: Congressional Research Service.

Average coal prices

The average price of coal delivered to electric utilities doubled in 1974 over 1973 in response to the nearly three fold increase in price of the residual fuel oil which utilities purchased. The chart (not printed) attached shows the dramatic rise in both coal and oil prices per million Btu and the relative magnitude of a $1.00 per ton coal cost compared to these increases. It is totally ridiculous to assert that H.R. 25 will produce rises in electricity costs similar in any way to the increases of the past year. Relief from high electric rates can only come from a lowering of oil prices—a policy the Congress favors and the Administration opposes.

Coal is used to produce approximately 45 percent of the electricity consumed in the United States. According to the most recent data released by the Federal Power Commission, the average price of coal to electric utilities in February 1974 was $17.71 per ton. Spot purchases are reported by FPC to average nearly $26.00 per ton, while the price of a ton of coal purchased on long-term contracts averages $15.71. Coal produced from underground mines is selling at $19.43 per ton on the average. The comparable figure for surfaced-mined coal is $16.64.

In October, 1973 prior to the embargo, the average price paid for coal by electric utilities was $9.34 per ton. The spot price, $11.24 per ton, was only slightly higher, and the contract price, $8.86 per ton, only slightly lower. At that time, coal mined underground sold for $10.58 per ton and surface-mined coal sold for $8.62 per ton.

Industry and utility views

The dramatic increase in coal prices paid by utilities since late 1973 has followed the nearly three-fold rise in the price of heavy fuel oil. This increase, stimulated by the OPEC cartel, permitted coal operators to charge prices which *averaged* nearly ten dollars a ton more than pre-embargo levels. Isolated spot purchases were even higher, in the $40 to $60 per ton range for coal which sold for $8 per ton a year ago. A brochure prepared for the National Rural Electric Cooperative Association entitled "Why Electric Rates are Going Up" indicates that NRECA expects to pay nearly $28.00 per ton for coal in 1975. These rapid price increases are unrelated to the cost of producing coal.

Given the coal industry's profit margins, it is ridiculous to assume that the industry cannot absorb the entire cost of H.R. 25—50¢–$1.50 per ton, for surface-mined coal. In most cases this is considerably less than 10% of the present price of coal.

As coal prices have been rising continually over the past 30 months, few complaints were heard from coal producers or even utilities. No attempt was made to reduce coal prices and nothing was said about the cost to the consumer of the soaring coal costs. Now, however, when producers face a minor cost-related increase rather than a net gain in profits, the industry has mounted a major propaganda campaign to exaggerate the potential burden the consumer may bear—particularly in the form of higher electric bills—because of H.R. 25. The inconsistency is glaring.

Much misleading information is being circulated by utilities about the cost of H.R. 25. A typical example of such deceptive propaganda is a press release put out by Southwestern Electric Power Co. of Shreveport, La. This release states that the bill cost its consumers $125 million for coal to be purchased under two contracts "at some future date". (The company now burns no coal at all.) What the company neglects to point out is that this cost (if and when it occurs) will be spread out over a 25 year period.

One of the planned contracts will be for lignite mined in Louisiana and Texas. SWEPCO estimates the reclamation fee for the lignite at 35¢/ton although the bill set a limit for the fee on lignite at 5% of the value of the coal (usually $1–3 ton) and thus the fee would be 5–15¢/ton. The $125 million total cost of the bill is thus considerably overstated. The company also neglects the fact that, for the lignite mined in Louisiana, one half of the fee is retained by the State. Yet even with all of these over-estimated costs, the increased cost to the SWEPCO consumer resulting from H.R. 25 is $4.97 million a year, or 4/100ths of a mil (.04 mils) per kilowatt hour, or $3.36 per year for a household using 700 kilowatts a month.

A more realistic presentation of increased consumer costs would be to show the cost of the bill on an annual and per kilowatt hour basis. Also, it would be more accurate to set the reclamation fee for lignite at 15¢/ton (assuming $3.00/ton coal) or less. This would, of course, decrease the total cost to the consumer by $1.44 million a year, or $36 million over a 25 year period.

The administration's analysis of consumer costs

If the propaganda on H.R. 25 being offered by the coal producers and electric utilities is misleading, the Administration's "analysis" of the consumer cost of H.R. 25 breaks new ground in ex post facto justification of a political position.

The fact sheet accompanying the President's veto message on H.R. 25 suggests that the legislation was rejected because if it became law "consumers would pay higher costs—particularly for electric bills—when consumer costs are already too high."

The President's use of this rationale for rejecting H.R. 25 is just astonishing. This Administration has been threatening the Congress for four months with what it calls an "energy program." The foundation and central feature of this program is embodied in the Administration's contention that the proper solution to energy problems must involve higher energy costs for consumers and higher profits for energy companies.

This is what the proposal to add $1, $2 and finally $3 to the tariff on imported oil is all about. This is what the decontrol of domestic crude oil and the deregulation of natural gas is all about. This is why the President proposes excise taxes of $2 per barrel on domestic crude oil production, and 37¢ per mcf on domestic natural gas. This is why the Administration's "Energy Independence Act" calls for faster and more complete incorporation of electric utility costs, including the costs of construction in the monthly electric bills for consumers.

The increased costs of the program which the Administration intends to implement without any new Congressional authority amounts to $33 billion on an annual basis. The Administration maintains that these costs are necessary, and that the Congress ought to permit them to be imposed. Moreover, the Administration has proposed legislation for Congressional action which would raise the $33 annual billion cost of energy for U.S. consumers by at least $10 billion more.

In view of these proposals and the Administration's repeated claims that high prices are the proper stimulus to conservation, the veto of legislation to control surface mining and reclaim damaged lands on grounds that it will raise energy costs is totally hypocritical.

What is the cost impact of H.R. 25? The fee imposed by the legislation averages approximately 25¢ per ton on all U.S. coal production. The reclamation costs will average perhaps 50¢ per ton when spread over all production. The administrative costs are at most a few pennies per ton. The total added cost of reclamation, estimated by the Administration, amounts to approximately $300 million dollars annually, to be imposed in 1978 and thereafter.

The Administration has proposed, and is insisting on enactment of, an energy program which will raise energy costs by at least 100 times this amount to be implemented this year.

In 1974 the average price of coal at the mine on a national basis increased by 76%, from $8.50 per ton to $15.00 per ton. Without comment from the Administration the price of average coal rose by $6.50 per ton. On the spot market, where many electric utilities make their coal purchases, prices have increased by as much as $20 per ton. None of these increases have gone into reclamation of strip-mined land. They have gone into the pockets of coal producers. All this has been acceptable to this Administration. Responsible legislation which reclaims the lad at a cost of at most $1 per ton is not.

The fact sheet submitted by the Administrator of the Federal Energy Administration, Frank Zarb, to the Senate and House Interior Committees on June 3 estimated consumer costs of H.R. 25 at $2.4 to $5.6 billion annually.

These estimates are based on highly dubious assumptions. It is also implied that H.R. 25 will cause higher prices and increased imports now in 1975— instead of in 1978 when the full impact of the bill would actually be felt. To obtain the Administration's cost figures, it is necessary to assume:

(1) That coal production will fall 40 to 162 million tons short of demand because of the provisions of H.R. 25;

(2) That no added coal production from surface or underground mines operating in 1978 in compliance with H.R. 25 will replace this "lost" production;

(3) That all "lost" coal production will be replaced by imported oil; and

(4) That, in response to a shortage of coal spot-market prices will rise by $12 to $18 dollars per ton.

The first two assumptions are questionable for a number of reasons discussed elsewhere. The third assumption clearly depends on the first two. The fourth assumption, that coal prices will rise by $12 to $18 per ton to the oil equivalent level is interesting in view of the Administration's repeated claims that President Ford's energy program, while increasing oil prices, will not affect the price of coal.

In fact, coal spot prices increased by $15 per ton in between October 1973 and February 1975. This price increase for coal occurred in direct response to the tremendous rise in the prices of imported oil. In fact, the price of coal has at this time reached an equilibrium with oil at a price significantly below Btu equivalency. There is no evidence that, without a further increase in oil prices, coal prices will again rise towards the $40–$42 which represents Btu equivalents with residual fuel oil. There is no question then, that coal prices do follow trends in oil prices. The Administration is now attempting to use this fact to grossly exaggerate the effects of H.R. 25. But because oil is a cleaner and more convenient fuel to burn than coal, the total cost of burning coal to utilities, including transportation and pollution control, will generally be higher. Hence the delivered price of coal is not ever likely to rise to the Btu equivalent price of oil. Thus it is unrealistic to assume anything like a $12–$18 per ton coal price increase because of the enactment of H.R. 25, particularly in the absence of a further major increase in the price of oil. The FEA's consumer cost estimates are thus totally without foundation.

Coal reserve losses

The Administration estimates that as a result of H.R. 25, some 17.0–73.4 billion tons of coal reserves would be "locked up". They claim that these estimates were derived from the estimate of production losses. However, there is in fact no direct relationship between coal production and reserves and the Administration has provided no explanation of the methodology used to make such a derivation. Nor do they explain the reason for their estimate that 14.2 billion tons of coal could be locked up by the surface owner consent requirements of the bill. Also, with respect to alluvial valley floors, representatives of the U.S. Geological Survey told the House and Senate Interior Committees in sworn testimony that the reserve loss estimates were made first, and the production losses derived later.

Nevertheless, insofar as it is true that the reserve losses are extrapolated from the production estimates, they must be considered highly dubious, since

the Administration's projections of potential output losses are, as noted earlier, exceedingly questionable.

Furthermore, these reserve loss estimates are predicated on the assumption that if certain reserves are closed to surface mining, they are inevitably lost. This totally ignores that fact that much of this coal can still be mined by underground mining methods, and is therefor not "locked up". The reserve loss estimates are thus greatly overstated.

Finally, the U.S. has some 434 billion of demonstrated recoverable coal reserves, enough to last more than 500 years. Even if one were to accept the Administration's worst possible estimate, we would experience a loss of about 17 percent of our total reserves, leaving more than 400 years' worth of reserves available for mining.

Appendix XI

Articles by Stephen E. Nordlinger (*Baltimore Sun*, June 30, 1975) and Ward Sinclair (*Louisville Courier Journal*, June 30, 1975) Dealing with the President's Veto of the Surface Mining Bill

[From the Baltimore Sun, June 30, 1975]

Coal-Veto Data Held Sloppy

(By Stephen E. Nordlinger)

Washington.—The figures on the loss of coal production cited by President Ford to justify his veto of the strip-mining bill appear to have been based on the roughest kind of estimates, verified in part by checking with state mining association officials who were known vocal opponents of the legislation.

Some of the material designed to substantiate the production losses was hastily assembled after the veto was announced, in preparation for a special congressional hearing called to examine the administration's figures.

A memo written at the Interior Department referred to some of the figures as "mushy" and said that supporting material might have to be assembled if they became subject to attack in Congress.

One Bureau of Mines official interviewed said that "a lot of guessing" had been done to compile the information to support the presidential veto.

Mr. Ford announced May 20 his veto of the bill to control environmental damage from strip-mining in Appalachia and in the Western fields. The House of Representatives by three votes failed to override the veto June 10.

The President's primary argument against the bill rested on a wide range of estimates of production losses going from 40 million to 162 million tons in 1977, when it was said the impact of the law would be felt by mine operators.

Although engineers and officials at the Bureau of Mines and the Federal Energy Administration developed this range, Mr. Ford and administration spokesmen emphasized the loss at the extreme upper end. Lobbyists representing the coal and electric utility industries ignored all but the top figure in their intense campaign to defeat the bill.

A three-week study of the methods used to compile the figures disclosed the following:

There was no economic analysis made of the small mines in Appalachia to determine their financial ability to comply with the bill's new requirements. An economic analysis would have studied the capabilities of the mines in light of expectations of high demand for coal and rising prices. The administration estimated that almost all small mines would be closed and few would be able to open as a result of the bill.

Thomas V. Falkie, director of the Bureau of Mines, promised at the special congressional hearing on the production figures to provide a list of the small mines that would be closed by the bill. In a later interview, Mr. Falkie said no such list exists, but that, if it did, he would keep it confidential on grounds that it contained proprietary information.

A chart submitted to the same hearing said that predicted tonnage losses from small mines were based on projections from examples "of approximately five operating mines" in seven states. The Federal Energy Administration refused to disclose the names of the mines, but John A. Hill, the deputy administrator, said a list would be made available using coded names for the mines. No such list has been provided.

Only an informal survey was made of state agencies, mining associations and mine operators, often by long-distance phone, in an attempt to verify the engineering estimates of the Bureau of Mines and the Federal Energy Administration. No fixed set of questions was used and no written responses were requested. The sheets noting the informal replies have been destroyed.

The check of mining association officials included B. V. Cooper, executive director of the Virginia Surface Mining and Reclamation Association, who organized the caravan of mine operators that demonstrated against the bill here April 9. Another official questioned, Keenus Bowling, represents the Interstate Mining Compact Commission that voted 5 to 2 in May, 1974, against the then pending strip-mining bill.

The professional engineers at the Bureau of Mines were directed to assume for their calculations of production losses a possible court-ordered ban on all strip mining that substantially affected the alluvial valley floors in the West. The

resulting estimate, not based on any formal study of the degree to which the mines could adjust the operations to the bill, accounted for a major part of the production-loss figures.

The scheduling of a special congressional hearing shortly after the President's veto to look into the production figures apparently triggered some intense activity at the governmental agencies to develop new substantiating information. The witnesses were to testify under oath about the figures.

Walter N. Heine, associate deputy director of the Mine and Land Protection in Pennsylvania and a supporter of the strip-mine bill, said the "phones rang off the hook" with requests for new information concerning the impact of the bill.

"It really frosted me that they wanted to do it after the fact," said Mr. Heine, who said he was "not too co-operative."

The request for new material was confirmed by William Kebbish, of the Bureau of Mines in Harrisburg, who said he was asked to seek the information by James Paone, director of the Environmental Division at the headquarters of the Bureau of Mines here.

"Everyone was questioning the figures you have so we were rechecking," said Mr. Kebbish. Mr. Heine said, however, that the Bureau of Mines had not checked previously with him or his staff for the kind of material requested.

In the months preceding the final congressional action on the bill, staff members of the Federal Energy Administration called by phone or visited officials in seven states in the East and South to get their assessment of the bill, according to a list supplied by the agency and interviews with government officials. The complex provisions of the bill were described on the phone in some cases.

One of the officials contacted, John Roberts, chief of the Division of Reclamation in Kentucky, the largest coal producing state in Appalachia, said that Fred Brokaw, of the energy administration. visited his office and discussed the pending legislation during a "general type of conversation." Mr. Roberts said that no formal questionnaire was submitted to his agency for information.

A list of seven industrial associations reportedly consulted by the Federal Energy Administration mentioned Ben Lusk, president of the West Virginia Surface Mining and Reclamation Association, but Mr. Lusk said in an inteveiew that no one from Washington contacted him about the bill, although he said he opposed the legislation. In a report to association members last October 4, however, Mr. Lusk said he thought West Virginia miners could "adjust properly" to the then pending bill, which was weaker than this year's measure.

One of those on the same list, William Keice, of the Alabama Mineral Producers Association, was selected by the coal industry to represent its views against the bill before the international executive board of the United Mine Workers of America in order to discourage union support of the legislation. The United Mine Workers of America later endorsed the bill.

Although the government relied on outside state and industry officials for appraisals of the lengthy, complicated bill and its consequences for coal production, apparently even the staff members of the Federal Energy Administration and the Bureau of Mines, presumably closest to compiling information entirely on the bill's impact, were not entirely conversant with the provisions.

During an interview last week, two officials, Daniel Jones, of the energy agency, and Buck Miller, of the mines bureau, said the legislation explicitly banned strip mining on slopes of 20 degrees or greater. No such provision existed in the vetoed bill, and, in fact, such a specific prohibition was deliberately omitted by Congress in Senate and House roll-call votes.

Both Mr. Jones and Mr. Miller were closely involved in assessing the impact of the legislation on coal production.

During two lengthy interviews with officials of the Federal Energy Administration and the Bureau of Mines, the production figures were strenuously defended, although the engineers indicated that they could not be responsible if only the most extreme tonnage loss calculations were cited by opponents of the bill.

According to Mr. Falkie, director of the Bureau of Mines, the figures were based "on our experience and the vast amount of data available." He said the bureau estimated that to qualify for a strip-mining permit the operator of a small mine would have to spend between $9,000 and $29,000 to meet the bill's mapping, hydrologic and other requirements, without assurance of receiving a permit.

This information was submitted to Representative Patsy T. Mink (D., Hawaii), chairman of the House Subcommittee on Mines and Mining, on June 17, but without an economic analysis of the ability of mines to cope with added expenses.

The report arrived a week after the veto-override vote in the House and almost a month after the President's veto.

Mr. Paone, of the mines bureau, said part of the projected production loss was based on an estimate of the number of mines the government thought might open by 1977 without a regulatory bill, although the mines are not operating now.

"We tried to make a judgmental evaluation," he said, based on the best available engineering experience.

[From the Courier-Journal, June 30, 1975]

Data Used To Justify Strip-Mine Bill Veto Questioned

(By Ward Sinclair)

Washington.—The lengthy, emotional congressional effort to put federal regulations on the strip-mining of coal was stymied last month when President Ford vetoed the bill on the grounds that it was too costly and too stringent.

The President made his case from a mountain of controversial statistics prepared to document the bill's impact. He said as many as 36,000 jobs would be lost and coal production in 1977 could be cut by 162 million tons if the bill became law.

The statistics were put together by engineers from the U.S. Bureau of Mines and the Federal Energy Administration (FEA). Mr. Ford's allies in Congress and industry relied heavily on the data and, on June 10, the House failed to override the veto.

One of the major environmental measures of recent years had gone down the tubes. And by putting heavy emphasis on eyegrabbing statistics and the "crisis" aspect of national energy needs, Mr. Ford and the industry were able to convert what had been essentially an environmental debate into a murky and heated conflict over jobs and tonnages.

During the past several weeks, numerous interviews and a review by this newspaper of procedures used by the engineers at FEA and the bureau produced some basic conclusions. Among them are these:

A systematic economic-impact study was not made to determine the mining companies' ability to pay for new costs the bill might cause. Bureaucrats "assumed" that companies, particularly small operators in Appalachia, simply could not pay and would go out of business.

Some impact figures were gathered after Mr. Ford had vetoed the bill. Some Bureau of Mines employes readily conceded that "a lot of guessing" was going on as the figures were prepared and that the data in some cases was "mushy."

Although most federal officials were cooperative after repeated requests for information, a pattern emerged: Background data was "destroyed," other material was "scattered" around the country, lists of names and mines became "unavailable" and officials complained openly about their figures not being taken on faith.

In other instances, statistics were drawn up from flatly erroneous starting points. For example, until last Wednesday, two key men in the data-gathering process thought the vetoed bill banned mining on slopes over 20 degrees. It didn't. In fact, both the House and Senate on roll-call votes specifically precluded any steep-slope bans.

Obscured in the debate, but crucial to the validity of the statistics, was the point that much of the projected "lost" production any many of the "lost" jobs do not exist today. The engineers estimated production goals for 1977 and then concluded the bill would prevent that future coal from being mined and, thus, the jobs from being created.

Given a near-impossible assignment to quantify losses that might occur, the bureaucrats came up with wide ranges of projections from which political figures—principally, Mr. Ford and FEA chief Frank Zarb—tended to emphasize the highest range of predicted losses.

Officials defended their projected impacts by saying they had carefully double-checked with companies, trade association and state reclamation agencies. A survey of those sources found that many were among the most vehement opponents of the legislation, who in turn were guessing about impact; others reported only cursory contact with the federal people.

After Mr. Ford vetoed the bill on May 20, congressmen and environmentalists leaped to the attack, arguing that the President's statistics were inadequate. Major supporters of the measure, such as Reps. Morris Udall, D-Ariz., Patsy Mink, D-Hawaii, and John Melcher, D-Mont., and Sens. Henry Jackson, D-Wash., and Lee Metcalf, D-Mont., were among the most outspoken.

Faced with rapidly eroding support in the House as members became worried about economic and energy impacts of the bill, Udall postponed a May 21 veto-override vote and announced that an Interior Committee inquiry on the statistics would be held in June.

The day-long congressional hearing produced a welter of arguments, contradictions and partisan sniping—in part because of the administration's refusal to provide all the background data that Udall and Mrs. Mink had requested in advance.

Since the hearing and the unsuccessful override vote, an exhaustive investigation and a series of interviews brought out an array of contradictions and discrepancies. Some examples:

FEA and the bureau insisted that part of the impact was determined by an FEA field survey of state reclamation offices, trade groups and selected strip-mining companies. This was done to confirm and double-check their own findings, they said.

FEA's survey was anything but formal or scientific. Each of the trade groups already was on record opposing the federal legislation.

Some interviews were conducted by long-distance telephone, some in person. No set of standardized questions was used. In some cases according to FEA engineer Dan Jones—the man who thought the bill banned steep-slope mining—answers were forthcoming only after FEA had read portions of the legislation to the interviewee and sought an expression of their impact on mining.

Jones' Alabama source was William Kelce. Kelce, of the Alabama Mineral Producers Association, in 1974 appeared before the United Mine Workers executive board to talk about why a similar bill pending then should be killed.

The FEA roll-call showed that a Kentucky source was Keenus Bowling, head of the quasi-government Interstate Mining Compact Commission, based in Lexington. In 1974 the compact voted 5 to 2 against the bill.

FEA's Virginia source was B. V. Cooper, head of the state's strip-mine operators who had organized and led a demonstration of miners and truck drivers in Washington in April—protesting passage of the bill.

According to FEA, its West Virginia source was Ben Lusk, head of the Surface Mining & Reclamation Association in Charleston. Lusk, contacted by telephone, said he had not been interviewed by FEA nor contacted for data. Had he been contacted, he went on, he would have "told them plenty."

Lusk publicly opposed the legislation. He praised President Ford after he pocket-vetoed a similar strip-mine control bill last December. Privately, in a newsletter to association members Lusk was assuring them that they could live with and comply with the bill.

Jones of FEA said he saw no conflict in that. Lusk, in the interview, reiterated his belief that passage of the bill would have been devastating to West Virginia strip miners.

Although the FEA contact list did not mention his name. Tom Duncan, president of the Kentucky Coal Association said he was contacted several times during recent months by government officials seeking the association's impression of the possible impact of the bill.

Duncan said the association believed the bill would be fatal to almost all small mine operators in hilly Eastern Kentucky. He said the impression was based on his group's knowledge of the industry and companies' financial resources.

"We felt by all logic anyone mining 100,000 tons or less in Eastern Kentucky could not survive," Duncan said. "As a practical matter we felt you could write off any production from mines of 50,000 tons or less. They couldn't survive, only a few tenacious ones could survive."

Duncan said the government officials who contacted the Kentucky delegation "were asking for honest answers and we tried to give them that * * * we don't want them to get their figures shot down. But there was no pressure of any kind on us to come up with anything."

As FEA and the bureau finally worked it out, they projected that of the 950 small mines in Kentucky they believed would be operating in 1977 without a federal law, 900 of them would have to close down if the law passed. In 1973, 632 small mines (50,000 tons or less) produced 9.9 million tons of strip coal in the state. The 1977 production-loss projection: 18.3 million tons.

Officials at the state level expressed some perplexity over reports that they had collaborated with FEA in compiling an impact assessment.

For example, John Roberts, head of Kentucky's reclamation division, said he was visited by an FEA official "probably in February" but their conversation was "only in the most general terms * * *."

Roberts said his greatest concern was that the pending federal bill might cause "paperwork problems" for the state and for mining companies, particularly with issuing permits. But beyond that, he said, the conversion dealt with few specifics.

Walter Heine, who directs the Pennsylvania reclamation program, said he had had no contact with FEA officials regarding potential impacts, although he said FEA might have talked to others in his state agency.

Heine said he was "really frosted" when he received a call from a bureau official asking for steep-slope mine data the day after Reps. Udall and Mink announced they would grill administration officials at a hearing. Heine said he felt the bureau was trying to put together data "after the fact" and he did not cooperate.

The bureau man who made the call, William Kebblish, based in Harrisburg, Pa., said he had indeed called Heine "about three or four weeks ago—when the congressmen were going to counteract the veto."

Kebblish said he had been directed by the bureau in Washington to make the contact "to recheck some of their statistics . . . everyone was questioning the figures, you know. I'm pretty sure this was when the committee was having their hearings."

Heine, after checking with staff assistants, said Kebblish had sought data about the number of steep-slope mines in the state and the number of mines producing 50,000 or less tons of strip coal yearly. Kebblish said he had sought the data.

Both FEA and the bureau said vital backup data to document and justify the final tabulations were not available. Jones of FEA said his agency's notes of conversations with the state groups had been destroyed because he saw no need to retain them once the final tabulation was made.

The tabulation, applying to steep-slope mines in the Eastern United States projected that a maximum of 52 million tons would not be produced from those operations in 1977 if the bill became law.

The same tabulation, delivered to Mrs. Mink after the June 3 hearing, indicated that "samples" of information had been obtained from "approximately five operating mines in each state."

The federal officials, both at the hearing and in interviews, have steadfastly refused to name the companies on the grounds that the data was collected on a confidential basis.

John Hill, deputy administrator of FEA, indicated to a reporter that he would authorize release of the economic data from those companies without naming any of them. Names were "proprietary," he said, and could not be given out.

But the list promised by Hill never was delivered. Queries to Hill's assistants at FEA failed to bring delivery of the data, although they continued to insist that the data exists.

There was more controversy and discussion of other lists. Bureau of Mines director Thomas V. Falkie told Mrs. Mink that his agency, along with FEA, had made a field survey that showed a mine-by-mine listing of companies that would not be able to comply with permit and bonding requirements of the proposed law.

At Mrs. Mink's insistence, Falkie told her he would supply the material to the committee. Different items have been sent to Mrs. Mink since the hearing, none apparently fitting the description of the data she shought.

Later, in an interview, Falkie said no such list exists and even if it did "we would not give it to you" for fear of jeopardizing the companies in some undefined future regulatory situation.

Falkie's bureau apparently had some of the same difficulty that FEA had in keeping records from its surveys. James Paone, head of the bureau's environmental division, which did the statistical work, said much of the back-up data was "scattered all around the country . . . in Spokane, in Pittsburgh and Denver." But some of it, he added, doubtlessly had been destroyed during the months since the study began.

The bureau and the FEA rejected several recent government-financed studies that indicate the cost of reclamation on steep slopes in Appalachia can be paid by small companies if current or higher coal prices prevail.

One such study was introduced in the Congressional Record last winter by Sen. Howard Baker, R-Tenn., who wanted the Senate to know that the Tennessee Valley Authority had found coal could be mined and the land reclaimed on steep slopes for less than $9 a ton.

Bureau engineers cast the report aside as inadequate. Another bureau-sponsored study by consultants, who found a slightly higher per-ton cost for similar mining, was discredited by engineers who thought the consultants wanted the bill passed into law to enhance their consulting business.

Lower-level employes at the Bureau of Mines said privately that at least one statistic, projecting minimum tonnage loss if the bill became law, was viewed as "mushy" and was revised downward to make it more immune from attack. Employes said the bureau, if need be, intended to come up with more specific statistics tailored to back up Falkie's public assertions about production losses.

In partial corroboration, Commerce Department counsel Ray Peck, lamenting public criticism of the statisticians' work, said that in at least one instance the administration told the engineers to come up with new figures because their calculations were "too high to be believed." Peck said they refused to do so—evidence of their professionalism.

Another bureau employe, minerals economist Walter Dupree, a recognized expert within the government, had a more straight forward view about the procedures used by the engineers and officials in coming up with statistics.

"A lot of guessing was going on," Dupree said, in explaining how they had come up with a projected coal tonnage loss between 40 and 162 million tons.

Although Dupree was a member of the statistical team and although colleagues good-naturedly hooted at him as he made the "guessing" remark, he was saying essentially the same thing Rep. Udall said as the congressional inquiry began June 3.

Udall accused administration officials of "guessing" that production would fall if the bill became law. Udall, predicting that production would increase, said he was "guessing too."

By then, minds had been set, opinions formed and votes committed. On June 10 the House failed to override the veto by four votes.

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